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THE SUN GOD OF THE KATCINAS, AS HE APPEARS AT THE ANNUAL CEREMONY IN HIS HONOR (SEE PAGE 329)

SCIENTIFIC AMERICAN MONTHLY

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Announcement

AS ANNOUNCED in the SCIENTIFIC AMERICAN of September 10th, the present weekly SCIENTIFIC AMERICAN and the present SCIENTIFIC AMERICAN MONTHLY are to be combined into a single monthly SCIENTIFIC AMERICAN. The first issue of the new combined monthly publication will bear the date of November, 1921, and will appear on October 20th. Succeeding issues will be published on the 20th of each month. This change has been determined for the following reasons:

In the month of January, 1920, the weekly SCIENTIFIC AMERICAN SUPPLEMENT, after forty-four years of publication, made its appearance as a monthly. The advantages appeared to be so many, the drawbacks so few, that the change was made with full confidence that the SCIENTIFIC AMERICAN MONTHLY would meet with approval. If letters of congratulation and increased circulation are the true test, the change has been an unqualified success.

For many months past the publishers have discussed the advisability of making a similar change in the parent publication, the SCIENTIFIC AMERICAN weekly. Here also the practical advantages to be gained greatly outweighed the drawbacks. Reluctance to make the change was due perhaps more to sentimental than practical considerations. We are free to confess that after bringing out the SCIENTIFIC AMERICAN week by week for over three-quarters of a century, we feel a twinge of real regret in making this break in the long continuity. It is done, however, for the very good reasons that, by combining the two present periodicals in a single monthly magazine, we can present the same material in a better balanced and better digested form, and at a far lower cost to the reader.

The position which the scientific weekly held seventy-five years ago, when the SCIENTIFIC AMERICAN was founded, is no longer a sound one. In 1845 the daily press gave the scantiest space to scientific matters. There was a real demand for a periodical devoted to the world's advance, which should not necessarily give such complete or such technical statements as the quarterlies and the annuals of the physicist, the chemist, the electrician and the engineer, but which should enable the intelligent reader to get a sufficient idea of what had been done, and to get this without waiting for the appearance of quarterly or annual.

Today this is no longer the case. The daily papers give excellent summaries of every scientific advance, of every invention of importance. As regards the mere function of a scientific newspaper, it is obvious that the weekly can compete with the daily no more than the quarterly could compete with the weekly. But the average reader is even more anxious today than he was yesterday, and similarly more competent, to know just how the new invention (which he sees announced in his daily paper) works, just what the new development in pure or applied science involves. The scientific paper that aims to tell him this, however, as explained above, can discharge the function far more effectively in the dress of a monthly than of a weekly. The same good sense that dictated the founding of the SCIENTIFIC AMERICAN as a weekly in order to fill the need that then existed, today demands that it be shifted into a monthly in order to do best what today it has to do.

This necessarily means that the new SCIENTIFIC AMERICAN will do so much of the work that has heretofore been done, first by the SCIENTIFIC AMERICAN SUPPLEMENT and for the past twenty-two months by the organ of which this is the final issue, that the continuance of the present monthly would involve a great deal of duplication. It seems altogether best, therefore, to permit the parent publication to swallow its child.

In the matter of contents and quality we can assure the reader of the present weekly and monthly that the new magazine, which will combine the two publications, will contain within its covers the best features and the distinguishing qualities of each.

A liberal share of space will be devoted to various departments, and to a complete digest gathered from all of the technical journals, domestic and foreign, and covering the general scientific happenings of the month in a condensed and readable form. We shall continue to print the best of the learned papers, read before technical societies, such as hitherto have appeared in the SCIENTIFIC AMERICAN MONTHLY. The new monthly will have the same sized page as the present SCIENTIFIC AMERICAN weekly, but will contain more pages than are found in four issues of the present weekly.

In these days of heavy taxation and high cost of living the question of price takes on special importance, and here it is that the change, combining the two periodicals into one magazine, affording opportunities of enormous economies in manufacturing, mailing, and in fact, in all the mechanical labor incident to production, enables us to make a very material reduction in the cost to our readers.

The subscription price will be $4.00 a year, and 35 cents a copy on the newsstands, as compared with $6.00 a year for the present SCIENTIFIC AMERICAN and $7.00 a year for the present MONTHLY. Subscriptions to either or both the SCIENTIFIC AMERICAN weekly and the SCIENTIFIC AMERICAN MONTHLY, which extend beyond October, 1921, will be adjusted and extended to equalize the difference in price.

The Recovery of Sulfur from Blast-Furnace Slag

Details of the Diehl Process, Recently Brought to Success in Germany

By Paul J. Mallmann, Sc. D.

FOR many years metallurgists have attempted to utilize the heat going to waste in the blast furnace slags.

Dr. Stead, of Middlesborough, in his presidential address delivered before the English Iron and Steel Institute, in May of this year, advocated again a careful study of this perplexing problem.

Sir Lothian Bell, of Middlesborough, with his progressive associates, spent sums untold in experimental work to attain this same end.

Ledebur, Lührmann and many other German scientists exerted great ingenuity and skill to secure a practical solution.

In the early nineties, Capt. T. J. Jones, of Homestead, Pa., spent large sums of money to obtain a satisfactory result, but unfortunately the practice of waste of materials, of every description, ruthlessly indulged in, at that time, in our country, and even today not abated, created an unsurpassable barrier to the successful completion of the experiments he had initiated to convert into a tangible profit, the heat of the blast furnace slag.

A satisfactory working plant for the disulfurization of liquid blast furnace slag has been installed by Prof. Dr. L. H. Diehl, of Oberhausen, at the Guttehoffnungshütte, and credit is due to this scientist for showing us how to exploit, on a commercial basis, the waste heat of the slag.

In his report to the Committee of Blast Furnacemen of the Institute of German Iron Masters, he gives an account of the successful results of his work, and the causes that led up to it.

At the outbreak of hostilities England promptly waged war on Germany's maritime commerce, and in a comparatively short time cut off the foreign supplies of raw materials of every kind, and especially such products as tended toward the German Empire carrying on her war industries and her battles.

Now before the year 1914, Germany imported annually, from foreign lands, some 1,250,000 tons of iron pyrites, sulfur blends and other raw materials needed in the production of sulfuric acid, which commodity had created for itself a yearly demand of 550,000 tons, forming not only one of the principal corner stones on which the entire proud structure of the German chemical industry was founded, representing not only the prime factor for the recovery of soda, but being of paramount importance to the belligerents, in the prosecution of the war, since it was needed in the manufacture of explosives, of gun powder, and of other implements of destruction.

Desperate attempts were made by German chemists to harness into war service Germany's vast native deposits of gypsum and anhydrites, but the attempt failed both chemically and financially.

The history of Germany's dire straights created by this sulfur shortage will probably never be told, and credit is due to Professor Diehl for his ingenious method of solving this critical problem—by the simplest of means—by utilizing the heat going to waste in the liquid blast furnace slag, and being able to convert a practical loss into a profit, to the blast furnace plant, by recovering an average of 33 per cent of the sulfur contents up to then discarded as waste, with the slag on the dumps.

Any plant employed to exploit a process for the recovery of by-products, no matter what they are, must be low in cost of construction; the process itself must be simple and cheap; the labor bill must be low; and to justify the process and plant employed, the product must show a profit when sold.

Arguing that virtually 20,000,000 tons of slag, with an average of one and a half per cent of sulfur—representing a yearly loss of 300,000 tons of this commodity—were wasted annually on the dumps, Professor Diehl left the experiments to extract the sulfur from the existing slag deposits to a future date, and decided to make use of the relatively high temperature at which the liquid slag leaves the blast furnace to recover the sulfur contents from the slag in its flow to the waste heap.

The Diehl process for recovering the sulfur contained in the liquid slag is based firstly, on the recovery of sulfurous acid (H_2SO_3) through the oxydation of the calcium sulfide contained in the blast furnace slag by blowing air into the liquid cinders, and secondly, on introducing into the liquid bath sulfate-like anhydrites or gypsum, and a blast of air.

The chemical processes which take place when the sulfur contents of the liquid slag is oxydized through air, and through sulfate of calcium, with the help of air, are of a simple nature.

The oxygen of the air forced into the slag bath converts, *i.e.*, oxydizes the calcium of the calcium sulfide into lime, which is immediately absorbed by the meta-silicate of the slag, forming ortho-silicates and liberating free sulfur, which is burned immediately, if an excess of air is present, or is carried off, as free sulfur with the gas, if the presence of oxygen is insufficient to cause its combustion.

The following formulas give the occurrence:

$$CaS + 3O + CaSiO = Ca_2 + SiO_4 + S$$

$$S + O_2 = SO_2$$

When calcium sulfate is the oxydizing agent the chemical reaction is illustrated by the following formula:

$$CaS + 3CaSO_4 + 4CaSiO_3 = 4Ca_2\,SiO_4 + 4SO_2$$

Now it must be observed that calcium sulfide and calcium sulfate cannot exist side by side in a molten melt, an occurrence which is possible when in a solid state; in a molten silicate melt the liberated lime is immediately dissolved and the transposition between the still-present calcium sulfide and calcium sulfate continues, as is shown in above formula.

Considering the low percentage of the sulfur contents of the blast furnace slag a remelt of the cold slag was out of the question under prevailing conditions and all efforts were concentrated on recovering the sulfur from the slag in its molten state.

A series of experiments conducted over a lengthy period finally produced the plant now in operation at Oberhausen; it would go too far to describe all these investigations and tests in detail, but a brief review of the same will be found instructive.

To ascertain working conditions and how the oxygen of the air would act on the molten slag, a zinc hood through which a pipe had been passed, was partly submerged in the flowing cinders on their way to the granulating pit; through this pipe air was blown and the gases accumulating under the hood were drawn off by a gas delivery tube, and showed on analysis that they contained 23.1 vol. per cent SO_2.

This experiment was followed by passing the liquid slag through a fire-brick-lined cast-iron vat, provided with seven pipes having flattened-out nozzles through which the air was forced into the molten cinders; this vat was closed with a brick-lined hood to collect the gas. When it was found that insufficient air reached the slag to ensure the desired disulfurization and the shape of the bath appeared also to be defective, it was decided to insert cast iron channels, drilled laterally into the floor of the vat; from these holes ten pipes protruded to secure a more uniform air distribution. The results gave a gas of 9.75 per cent sulfur dioxide and 4 to 9 per cent oxygen (by volume), resultant gas well adapted for the manufacture of sulfuric acid, and other commercial commodities, but the insufficient disulfurization of the slag proved that an insufficient air volume had been introduced into the liquid cinders; this was due to the round shape of the nozzles,

and proved that the air introduced through flattened-out tuyeres gave a better result. Another useful observation was that the satisfactory progress of the process demanded a finely distributed air supply, which should pass through the highest possible layers of slag, under not too high a pressure.

Other difficulties included burning of the tuyeres, due to the fact that they were made of gas piping; the molten cinders clogging the nozzles; the clearing of the bath of the slag scales —work made difficult because the tuyeres protruded some six to ten centimeters into the vat. These were all overcome as herewith briefly described by the plant now in operation:

The construction of the bath with the permanent hood and chimneys is to be seen from drawings AB, CD, EF, GH, IJ, KL, and MN. The apparatus built into the path of the blast furnace slag run, consists of an outer structure a, a1 (through which the blast pipes k pass), supports the permanent vault b, on which is mounted the chimney c, into which the gases produced by the process pass.

The bath, or vat proper, of a total length of 3.745 meters, consists of three parts, a2, a3, and a4, cast from best foundry iron, each part of two sections, the upper and the lower, and into the upper section cooled pipes are cast, while the lower, or bottom part of the vat is channeled shaped, widening out toward the discharge end of the vat, as can be seen in drawings IJ, KL, and GH.

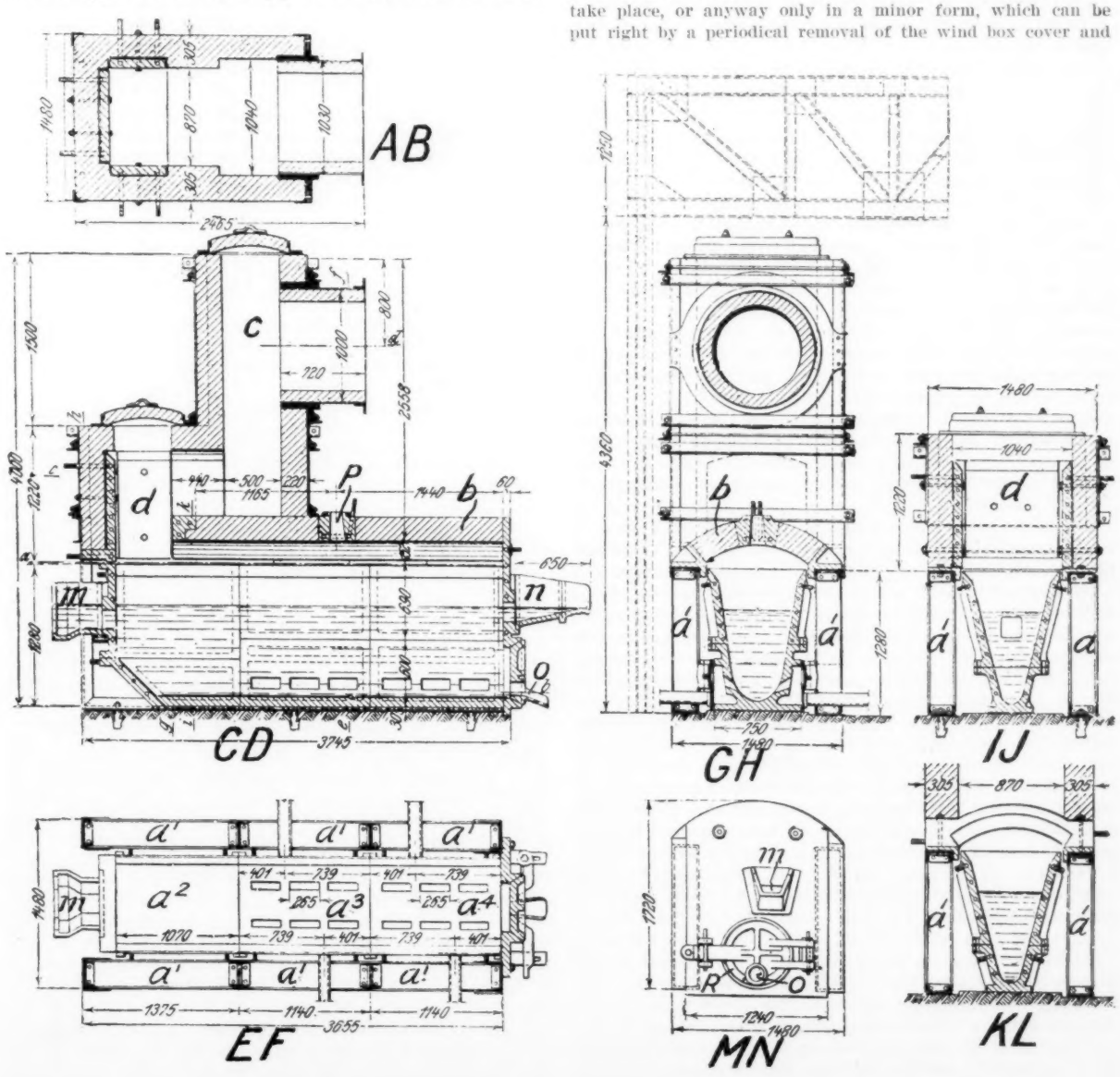
The channel-shaped sections a3 and a4 are provided with six openings each to permit the insertion of the tuyeres, as shown in drawings CD, EF and GH.

From the receiving receptacle m, the liquid slag enters the bath, the blast having been turned on in the meantime, rises in the bath till it reaches an elevation level with overflow nozzle n, and is drawn off through taphole o, on completion of disulfurization; when the bath had been emptied the door r is opened and any scales formed in front of the tuyeres removed; through the aperture p, the anhydrite additions are made.

The principal dimensions are shown in the plans of the bath which has a daily capacity of treating 180 to 240 tons of liquid slag.

OBSERVATIONS AND CONCLUSIONS ON THE WORKING OF THE PLANT

Provided that the initial air pressure is high enough and the molten slag enters the bath at such a high temperature, and at a sufficient speed, that the slag does not freeze and form a thick crust, a closing up of the air tuyeres does not take place, or anyway only in a minor form, which can be put right by a periodical removal of the wind box cover and



THE DIEHL SULFUR-RECOVERY INSTALLATION; FOR FULL DETAILS SEE TEXT

cleaning out of the slightly clogged tuyeres, an operation which does not seriously retard the operation of the process.

The apparatus must be well heated and the slag must enter the bath real hot.

The initial blast pressure must be raised from 10 centimeters mercury column to 18 centimeters, and must be retained at that pressure, unless sponge-like frozen slag scales within the bath and right in front of the mouth of the tuyeres are formed, when the pressure must be raised to 24 centimeters; this sponge-like scaly slag formation is intersected by a series of numerous fine wind channels, through which the blast passes into the liquid slag, in a finely divided spray; the flattened out slits of the tuyeres are found to remain perfectly open and free from entering slag when the previously mentioned sponge-like slag scales settle right in the beginning in front of the tuyeres, thereby protecting the tuyeres against the entry of liquid slag.

At the end of the slag run the slag scales and these previously described spongy slag formations are removed from the bath; this opens up again all the tuyeres.

The provided for, previously described permanent vault, is kept free absolutely from slag, and therefore, need not, as had been anticipated, be removed, and there is no need to provide it with an arrangement for either opening or removing the same.

The yield of sulfur is the larger, the hotter and the richer in sulfur the entering slag is, and the composition of the slag as such is also of great importance, because acid and highly soluble slag gives off sulfur more easily and more freely than pronouncedly basic slag; on the other hand the highly basic slags are, as a rule, richer in sulfur, and generally hotter, showing satisfactory disulfurization as a result.

The change in the appearance of the slag, after air treatment had taken place should be mentioned. As it is known, slags of high calcium sulfide contents are milky and cloudy in appearance, caused by the ejection of the crystalline needles formed; this is particularly the case with hematite slags.

Such milky perturbed slags become absolutely clear and glassy by the treatment under review, which proves that the procedure of disulfurization progresses as previously described, namely, that the calcium sulfide is burned and the lime thus formed is dissolved in the slag. In rare cases, particularly if the slag is very rich in sulfur, and an insufficient volume of air is introduced to assure a perfect combustion of the calcium sulfide, elementary sulfur appears and the gas obtained is poor in oxygen.

The procedure is similar to the one which takes place in the combustion of hydrogen sulfide when insufficient quantities of air have been introduced, where the oxygen of the air, the affinity of which is greater for hydrogen than for sulfur, and the affinity of which is greater for calcium than for sulfur, combines in the instances cited, with hydrogen, and in our case with calcium, freeing in the combination elementary sulfur. Though this occurrence has up to now not been utilized for the recovery of free sulfur, it still gives an explanation for the appearance of a large, long flame when air is blown through hot liquid slag, rich in sulfur, when the oxygen forces the sulfur out of the calcium combination and the sulfur so produced is carried along by the forced-in air as sulfur fumes, burning with the previously described long flame. The sulfur flame, however, is not pale blue as one should expect, but of an intensely white glare of violet shine. The glare of the flame is produced by the evaporation of the potassium hydroxide contained in the slag, which shows itself as a white fog when the gases have cooled.

When the gases are drawn off through iron pipes, the inner walls will be coated in due course, with a white salt, which consists almost exclusively of a potassium bisulfate, with a low addition of, say, 2 to 3 per cent of sodium bisulfate.

An alteration of the process consists in oxydizing the calcium sulfite of the slag in part, or in whole, by using sulfates, principally calcium sulfates, introduced at the time when the air is blown in. By doing this a very rich gas is produced, the sulfate is entirely decomposed and after this treatment there is no more sulfate of sulfur found in the slag, but only a residue of sulfur sulfides.

The temperature of the gas produced by the process is about 930 to 950 degrees Centigrade, when measured at a point situated beyond the radiation influence of the liquid slag.

Tables No. 1, 2, 3 and 4 show the results obtained with different kinds of slag.

Table No. 2a shows the average results obtained during six months' run from Thomas Pig Iron production:

Table No. 1. Air Treated Blast Furnace Slag of the Thomas Process

Condition of the Slag	Slag at Entry %S	Slag at Exit %S	Sulfur Yield in % of the Slag Weight
Good, warm	1.31	0.79	0.52
Good, warm	1.23	0.75	0.48
Long, cold	1.42	0.96	0.46
Long, slightly warmer	1.33	0.84	0.49
Good, warm	1.42	0.89	0.53
Good, warm	1.51	0.96	0.55
Cold, foaming	1.54	1.04	0.50
Cold, short	1.23	0.73	0.50
Good, long, warm	1.76	1.10	0.66
Good, warm	1.46	1.00	0.46
Good, warm	1.47	0.96	0.51
Good, warm	1.84	1.36	0.48
Good, hot	1.83	1.14	0.69
Well boiled, hot	2.03	1.25	0.78
Fairly warm, foaming	1.57	1.09	0.48
Good, warm	1.34	0.88	0.46
Good, warm	1.32	0.84	0.48

Table No. 2a shows the average results obtained during a number of months from slag produced by foundry iron production; table 2b the results obtained from hematite slags.

Table No. 2a. Air Treated Blast Furnace Slags: Origin Foundry Iron

Slag at Entry %S	Slag at Exit %S	Slag Yield in % to Slag Weight
2.35	0.97	1.38
2.21	1.15	1.06
2.35	1.34	1.01
2.44	1.26	1.18
2.44	1.19	1.25
2.45	1.20	1.25
2.40	1.15	1.25

Table No. 2b. Air Treated Blast Furnace Slags from Hematite Iron

The slag was throughout very hot; after freezing its appearance was yellow white and the segregated sulfur calcium gave it a strong cloudy, milky appearance, but by blowing air into it, it became glassy and transparent. During the blowing, flames of burning sulfur six meters long, appeared at the top of the chimney.

ANALYSIS OF THE SLAG

Slag at entry .....2.26 % S
Slag at exit .....1.03 % S
Yield of sulfur.....1.23 % S

ANALYSIS OF THE GAS

SO_2 Vol. % 10.37
CO_2 Vol. % 1.2
O_2 Vol. % 3.8
N_2 Vol. % 84.63

Table No. 3 gives the result obtained by treating Thomas slags with air, and an additional introduction of anhydrite ($CaSO_4$). The added anhydrite gives up 25 per cent of its sulfur contents in weight which naturally increases the ultimate production of sulfur.

Table No. 3. Air Treated and Anhydrite-Improved Blast Furnace Slag from the Thomas Process

The Condition of the Slag	Anhydrite Addition	Slag at Entry	Slag at Exit	S. Yield in % of the Slag Weight	
				From the Slag alone	From Slag and Anhydrite
Good, warm	0.66	1.56	1.01	0.55	0.68
Good, warm	0.625	1.29	0.82	0.47	0.62
Short, cold	0.65	1.35	0.89	0.46	0.61
Good, long	0.40	1.66	1.10	0.56	0.66
Good, hot	0.80	2.24	1.47	0.77	0.97
Good, warm	0.75	1.83	1.25	0.58	0.76
Average	0.60	1.41	0.86	0.55	0.70
Good, hot	0.675	1.70	1.09	0.61	0.78
Well done, hot	0.60	1.70	1.03	0.67	0.82
Short, hot	1.18	1.98	1.27	0.71	1.00
Well done, warm ..	0.75	1.88	1.32	0.51	0.69
Long, warm	1.40	1.45	0.89	0.56	0.91

Table No. 4 shows the average sulfur contents in gas obtained from similar slag, averaging over a number of months, but without the addition of anhydrite. It will be found that the oxygen contents of the gas is quite sufficient to justify the conversion of its sulfur dioxide contents into sulfuric acid, either by the chamber or contact process.

Table No. 4. Composition of the Sulfurous Acid Gas

The gas produced from the slag contained 9½ to 10½ Vol. % oxygen.

Without Anhydrite Addition to the Slag Vol. % SO_2	With Anhydrite Addition to the Slag z z Vol. % SO_2	Without Anhydrite Addition to the Slag Vol. % SO_2	With Anhydrite Addition to the Slag Vol. % SO_2
5.70	7.27	3.60	8.46
4.93	6.34	8.19	10.34
5.11	5.63	5.77	7.76
4.50	7.57	6.11	7.66
5.63	10.85	6.51	6.37
8.09	9.95	7.10	7.17
7.58	6.81	8.39	6.37
5.03	8.19	8.96	6.86
6.20	7.78	9.85	6.97
5.92	8.88	5.57	14.11

The gas produced by the Diehl process contains an average of from 6 to 7 volume per cent of sulfur-dioxides with smaller quantities, generally speaking of 1 to 1.1 volume per cent carbonic acid, about 10 volume per cent oxygen, with the balance consisting of nitrogen. It is recognizable by the absolute absence of arsenic, chlorine, fluorine, carbon-oxide, sulfur, dust or impurities of a similar nature, but does contain small quantities of potassium bisulfate, from which it can be freed very easily. Therefore, it is preeminently suitable for the production of pure sulfur products like liquid sulfur dioxides, sulfites, particularly sodium sulfite, sodium bisulfite, calcium bisulfite liquor, sulfuric acid, and fuming sulfuric acid, produced by the contact process. In this process the stored up and up till now not utilized temperatures of the liquid slag are made use of, and at the same time the liquid silicic acid, and the liquid alumina contained in the slag are made use of to dissolve the intermediary formed sulfites and sulfates, and this is done without consuming new combustion material, which irrespective of the high cost of fuel prevalent today gives the great advantage that the obtained gas is practicably free of carbolic acid, and absolutely free of carbon oxides. Besides this, it is entirely free of the most objectionable of impurities, arsenic, because arsenic as far as it occurs in the iron ores is reduced in the blast furnace process, and enters the iron. The oxydizing blast of the air excludes almost a trace-like occurrence of arsenic in the basic slag, but should exceptionally small quantities of arsenic be found in the slag then it appears as arsenate of calcium salts.

The treatment of slag with air or anhydrite is not detrimental to the subsequent use of the slag. It can be granulated just as before treatment, and for other purposes, as for building material, etc., it becomes even better, because it is freed of its sulfur contents.

The cost of production of this gas is low, because the man attending to the slag requires one assistant only for the work of the slag bath. To this is to be added the very small expense for blast, approximately 1½ per cent of the wind consumed by the blast furnace proper; besides this, there is the repair of the bath which confines itself to the occasional replacement of a burned tuyere, and to a new pouring spout.

When anhydrite is used, the price at which it is delivered to the works has to be added, but it has to be considered that every ton of anhydrite yields one-half ton of pure sulfur dioxide, irrespective of the gas from the sulfur of the slag.

CONCLUSION

The Diehl Process answers all the conditions a by-product recovery process and plant should fulfil. It is simple and inexpensive as to the process, and it possesses the great advantage of delivering the slag in a better condition to the dumps after treatment, than before, since the slag freed of its sulfur contents makes better building material, be it cement or brick, than before.

The heat contained in the liquid slag—up to now going to waste—in conjunction with the forced introduction of air, with or without additions of anhydrites, liberates the sulfur in combination and gives the blast furnace industry a useful and paying by-product, which again does not contain many of the objectionable constituents, which render a by-product either useless or too expensive for subsequent use, and sells readily.

The plant employed is simplicity itself and may be well termed a converter ingeniously adapted for the judicious utilization of the waste heat and wasted materials of the slag up till now the cause of annoyance and worry to the iron master.

The cost of building the plant is low; operating it is cheap, because it requires actually one extra man only per shift.

Professor Diehl is to be congratulated on the ingenious and simple manner in which he has solved a vexing question satisfactorily and profitably, and our metallurgists will do well, not only in applying the lesson taught, to prevalent American practice, but also following his line of thought, attempt to solve another difficulty, namely, of profitably extracting the sulfur contents of the slag now lying in millions of tons on the waste heap.

FROSTED GLASS

In order to produce a matt surface on glass T. Ueda of Kyoto coats the glass with a substance (alkali silicate, basic lead silicate, lead salts) which when heated reacts on the glass to form a product decomposible not only by hydrofuric acid, but also by sulfuric, nitric, or hydrochloric acids. The powdered composition further contains an inert agent (powdered porcelain, stoneware, fireclay) and a binding agent (gum).

Owing to the necessity of clearing the presses for the November issue of the new SCIENTIFIC AMERICAN, with its much larger run than that of the present Monthly, we are forced to go to press without waiting for the usual notes detailing the month's progress in mining and engineering. We regret the absence of this feature.

Gypsum as a Building Material

The Causes of Its Failures and the Way in Which It May Be Used with Success

By Leo Griswold Hall

GYPSUM is one of our available building materials which is becoming more and more widely used, but which is as yet not very generally known, and has not consequently approached the limit of its usefulness in practice. The slowness with which it has obtained recognition as a standard construction material has also been in part due to many failures in its use in the early stages of the game. These failures were not so much due to the inability of the gypsum to lend itself to use as a dependable structural material, as to lack of care on the part of early designers, and their failure to allow for certain definite qualities in the material. Many failures naturally resulted, which have tended to give gypsum a black eye with the building trade; and many engineers, hearing of the failures, and unacquainted with the reasons for them, have simply passed gypsum by, where they could have made very substantial economies by its use. The early history of reinforced concrete is full of just such failures and prejudices. Properly used, gypsum is just as reliable as reinforced concrete—in their relative spheres.

As it comes from the mine, gypsum is a very soft grayish colored rock, with a slightly soapy feel to it. It occurs very widely in beds which vary from a few inches to several feet in thickness. It is mined in quantities in New York, Ohio, Michigan, Illinois, Kansas, Texas, California and Washington, and large deposits occur in many other states. Other varieties of the same material are known as gypsite and alabaster.

Chemically, it is a hydrated sulphate of calcium. To be made ready for use it is calcined, driving off most of the water of crystallization; an impalpable white or grayish powder resulting. This is the plaster of paris of commerce.

The calcined gypsum has a great affinity for water, combining with about 17 per cent by weight of the latter, to reenter the crystalline state, or in other words, to set. This setting takes place completely in a very few minutes—almost instantly, if there be no excess water present. It can be greatly accelerated by throwing in a handful of crystallized gypsum, to form a nucleus of crystallization. In fact in casting it is necessary to keep molds, etc., entirely cleaned after each use, to avoid setting the gypsum before there is time to work air bubbles to the surface and see that the molds are properly filled. This, together with its strong tendency to stick to everything with which it comes into contact, are the most disagreeable features of its use. This disadvantage is, however, more than made up for by the rapidity with which molds can be re-used. But I anticipate my subject.

The use of gypsum in wall plaster and moldings is so well known that I shall not go into it here. Its use in a manufactured wall board, usually rolled between heavy layers of card board is but little less known. It is manufactured in this form, I believe, by several well known companies; and when so made up, yields itself readily to any use to which wall board may be put; being readily susceptible to sawing, nailing, etc. It is a remarkably good heat insulator, and is frequently used in the walls of refrigerators, etc., more than one thickness usually being used, and protection from damp and from mechanical injury being necessary.

The use of gypsum, either cast in place, or in precast tile form as a roof or floor deck is not so well known, though this is one of the uses to which it may be put with a great deal of economy. Its high heat-insulating qualities render it a fuel economizer of no mean qualities, when used in the roof of buildings in cold climates. Its extreme lightness of weight renders worth-while economies in steel design possible when used in steel frame buildings. Its rapidity of setting, permitting forms to be removed and re-used immediately after casting, allows great economies in form materials. These, together with its high fire resistant qualities, render gypsum a very desirable structural material under the proper conditions of design, etc., for its use.

But here it is that failures have occurred, which have been due to faulty design, but which have none the less tended to give the whole gypsum slab proposition a black eye. These difficulties of design can none the less be successfully overcome; have been so in very many cases, and there are standing today very many gypsum floor and roof decks in good condition after several years' hard service. Slabs 4 inches thick over a 10-foot span are designed to hold a live load of 70 or 80 pounds per square foot, with a fair safety factor. I have myself tested a slab of 6-foot span, 3½ inches thick and 20 inches wide, entirely unfixed at the ends to destruction under a central load of 1400 pounds. This is equivalent to a uniformly distributed load of about 280 pounds per square foot. Nor was this slab specially made for test purposes. It was taken at random from a lot made for a factory roof. Others have at different times stood up in proportion. Now as to the cause of failures.

Gypsum, though it possesses some structural strength, possesses very little by comparison with cement, or any of the natural or artificial building stones. It is usually used for lightness sake mixed with chips, to give it body, but which do not add any appreciable strength to it except perhaps in sheer. Its strength in tension is at all times negligible. It has, however, in compression, a certain comparatively small but dependable strength or stiffness, *when dry*.

It is usually cast for ease of handling with a great excess of water above the minimum required for complete crystallization. When set, it is hard enough for ordinary careful handling; but the maximum strength is not attained until this surplus water is evaporated out of the mass, which may take anywhere from a few days to a few weeks, depending on the weather, conditions of exposure, etc. The drying in the case of present slabs is frequently hastened by the use of kilns.

Gypsum decks have been usually designed with reinforcing so that they are amply safe *while dry*. The reinforcing is so designed as to subject the gypsum to no tension, very little sheer, and to a certain amount of compression, which the dry gypsum is easily capable of withstanding. But what is not always taken into account is the fact that the gypsum loses the greater part of this compressive strength when wet.

Being used frequently for the roof deck of a heated building in a cold climate, without protection on the under side, there is a tendency to condense moisture on the under side of the slab. The gypsum, being very porous, and having great avidity for this moisture, absorbs it as fast as it forms, becoming itself softened thereby, frequently in long continued cold, to the point where a very ordinary load produces failure. Also, after having absorbed a considerable amount of moisture, if the building is left unheated for a while in very cold weather, the absorbed moisture may freeze, causing extensive cracking and flaking. These are the main causes of failures: witness the fact that over 90 per cent of failures are on roofs; not on floors where there is little tendency to condensation.

There are two ways to tackle this difficulty. The first is to design the reinforcing so that it will stand without depending on the gypsum except as a filler. The second is to protect the gypsum so that it cannot absorb moisture. And there is perhaps a combination of these two in the sheet metal arched cell construction of recent years so frequently used with concrete. The sheet metal domes, corrugated or otherwise deformed for strength's sake, being left in place, both

as a reinforcing to the gypsum and as a protection from moisture of condensation on the under side. I do not know of any case where this has been done, but I believe it would be highly successful without involving the use of a greater weight of metal per square foot of slab than is now commonly used under conditions of equal strength in practice.

The common method of reinforcing gypsum slab today—and the most successful one—consists in stretching cold drawn steel wire at right angles to the purlins across the deck usually consisting of several spans, and anchoring securely to a special member for the purpose at both ends. The wires are spaced variously from 1½ inches to 4 inches, depending on the designed load. In the center of each span, a transverse bar is then placed on top of the wires, being pulled down to the forms and anchored there. Under the wires and lying transversely with them on top of the purlins are small angles or bars, supported above the purlins and supporting the wires above them. The wires are under high tension and run zig-zag in a vertical plane; being in the top of the slab at the purlins and in the bottom of the slab in the center of span. The transverse bars, both top and bottom, are of sufficient size to present considerable surface to the gypsum in a vertical direction, and to minimize the possibility of their shearing up or down through the soft slab, as the wires alone would be very likely to do. The bars are usually so placed as to be about three-fourths of an inch clear of the surfaces of the slab for fire protection.

As the wires run continuously through the deck, and are tied securely at the ends, there is no way in which this form of slab can easily fail, so long as sufficient area of steel is present to prevent sheering through, and so long as there is sufficient area on top of the purlins to prevent failure by direct compression of the gypsum between the top bar and the purlin. Under proper design, this is not liable to occur even while there is no excessive width on top of the purlin.

I have knowledge of some thirty or forty factory roofs whereon this type of construction has been used; and of these, but one has been a failure. This was a case where a great deal of steam was used in the building, softening the gypsum to an unusual extent, while insufficient bearing area to allow for such softening was provided on the purlins.

Gypsum as usually cast with wood chips is very elastic, and lends itself readily to a system of reinforcing which is itself so elastic that I have tested a 3-inch slab of 6-foot span to the point where it sagged 2 inches in the center of span under load, and instantly recovered when the load was removed. The grip of the gypsum on the wires (in this case 3-16-inch cold drawn) is shown by the fact that these did not slip through the gypsum though they were not fastened at the ends. The slab which I mentioned in the early part of this article as having been tested to destruction, failed by slipping off the wires, which were not fastened at their ends. In practice the entire reliance is placed on the tying of the wires at the ends; the grip of the gypsum on the wires being simply an added safety factor, which largely diminishes when the slab is wet.

As I have said above the weakest point of this design lies in the possibility of the gypsum crushing between the purlin and the top bar. This is in some cases obviated by the use of wide bearing plates on top of the purlins and under the slab. This, of course, adds expense. I shall have more to say about overcoming this weakness later.

There are a number of types of precast tile on the market which are intended to be used in place of the deck cast in place. Some of these are flat and are intended to be fastened together at the joints—the reinforcement being tied, and the cracks being filled with gypsum grout, forming to all intents and purposes a single slab such as I have outlined above. Others are intended to act as individuals so far as their reinforcement goes, each tile standing by itself without connection with the next. They come in several shapes—flat, inverted U section, flat hollow, etc. It is in the independent tile that most of the failures of gypsum construction have occurred; for it is very difficult to devise a reinforcement, that is completely self-contained and which will stand without depending too much upon the varying strength of the gypsum, and which at the same time is sufficiently cheap to be profitable. So far as I am aware, this has not yet been successfully done. The inverted U type, wherein the adjacent vertical legs of two adjacent tile form together a beam, thus permitting a reduction of thickness of the slab, and a corresponding reduction of weight, seem to have the disadvantage that the thinner slab permits condensation to occur more readily. The only two cases of this type of roof I have seen failed for that reason. Of course, in the case of a floor slab where condensation is less likely to occur, this objection is largely nonactive. The hollow tile of various forms are helpful in that they tend to reduce condensation; and where that takes place, they tend to retard the spread of the moisture into that part of the tile which is under greatest strain under the usual conditions of reinforcement.

There are, of course, many types of reinforcement which can be made successful for individual tile under certain conditions, and which are cheap where the span is very short. Of these I might mention wire mesh stretched over a rectangular steel frame of nearly the size of the tile, and bedded in it. I have made and tested several of this type, and obtained very high strengths for spans up to 3 feet and thickness of 2½ inches. For spans of this length, the steel frame can be so light as to be very cheap. But the weight of the members of the frame increases more rapidly than the span, eliminating the economy of this type of reinforcement when this span is exceeded. This same objection applies to all types of reinforcement for individual and unconnected gypsum tile with which I am familiar.

If gypsum can be so used as to be kept from absorbing moisture, it may be depended on for a certain amount of structural strength of its own. This dry strength is sufficient to obviate much of the reinforcement difficulty mentioned above. But in keeping it from absorbing moisture, we run into another problem which has not, so far as I know, been solved commercially, but which must be solved before gypsum can come wholly into its own.

Many materials have been tried as damp-proofers for gypsum. Asphalt, various oils, paints and glazes, as well as waterproofed fibre sheets have been used for this purpose; but with little success. The great difficulty with all of them has been that they do not adhere permanently if at all, to the surface of the gypsum. The dry gypsum surface readily rubs off into powder, making it exceedingly difficult to obtain a permanent bond. The oils do not penetrate, so far as my experience goes, but either evaporate or flake off with the surface gypsum in a comparatively short time. Paints having water as a solvent seem to be the only ones which penetrate; but they do not waterproof. And though men interested in the problem have been experimenting for some years, the writer believes that this problem is still unsolved, at least by any process cheap enough for commercial purposes. Yet there is nothing intrinsically impossible in it. I have, after some experimental work, succeeded in transforming the surface of gypsum blocks into calcium silicate, a very hard insoluble substance, by the use of a suitable treatment. While this treatment does not close the pores, but still permits water to be absorbed, still the treated surface readily bonds with many waterproofing compounds which do fill the pores and permanently adhere. The net effect is to case harden the block. Nor does the hardened case show any tendency to break away from the body of the block.

I have immersed blocks so treated in water for several days with an absorption of less than 2 per cent. Blocks so immersed, when tested, showed the full strength of the dry block, and when broken, appeared dry clear through.

I am not yet prepared to go into details regarding this treatment. The chief obstacle to its use is its high cost, which

renders it prohibitive for use on a large scale. I am experimenting further in an attempt to get over this difficulty. I had a rather amusing experience when I found that asbestos or magnesium carbonate when used with gypsum under certain conditions caused fibri-crystalline growths to appear on the surface of the block. These proved on analysis to be epsom salts!

But the results which have been obtained are sufficiently encouraging to warrant the belief that the thing will be done commercially before long.

I have been able to vary the thickness of this case hardening up to one-half of an inch by varying the length of treatment. There is nothing in the process apart from cost of materials which would not yield itself readily to being done on a large scale in quantity production.

Of course, such an accomplishment, if it can be done sufficiently cheaply, will immediately open to gypsum a much wider field in the construction industry than it has hitherto occupied. In the first place, it will render it possible to use thinner tile for roof decks. It will make possible the simplification of the reinforcing of these tiles to some extent. It will render the use of composition or tar and gravel roofing on top of the roof deck unnecessary. In addition to making gypsum more reliable and simpler under conditions where it has hitherto been used, it will make it possible to put it to use in fields hitherto impossible—such as in building blocks exposed to the weather; walls cast in the same way as concrete walls are cast; shingles similar to asbestos shingles; outside ornamental work;—indeed, there is no reason why a whole building could not be built of gypsum.

Gypsum is one of the cheapest of materials—being far cheaper that cement or brick; and its use in fields now exclusively occupied by those materials would immediately bring down considerably the cost of building. Its extreme lightness of weight makes it possible to reduce considerably the amount of steel frame of buildings where gypsum is used. Its low heat conductivity makes gypsum roofed or walled buildings easy to heat in winter or to keep cool in summer; and renders gypsum a very good fireproofing material. The water of crystallization must be calcined away before gypsum loses its strength. With a lower heat conductivity than concrete, and a greater percentage of water, this calcination occurs in walls of equal thickness, more slowly in gypsum than in concrete, with consequent better fireproofing abilities in the former. Indeed, with proper weather proofing, gypsum should rise to a position second to none as a structural material. It can be used without waterproofing now in any place where it is not subject to weakening by the influence of moisture, or where its strength is not depended on except as a filler. But until it can be commercially waterproofed, its use is confined to such cases.

Following are a few facts relating to gypsum for those interested in its use:

(1) Gypsum is a hydrated sulphate of calcium of the formula Ca SO_4 plus $2H_2O$. It occurs in crystals. A granular form of gypsum is called alabaster. Another form containing a high percentage of impurities is called gypsite.

(2) Gypsum is difficultly soluble in hot and cold water.

(3) To be made ready for industrial use, gypsum is calcined, driving off most of the water of crystallization, and ground to a powder. On coming into contact with water again, it takes up this water of crystallization again, becoming hard, i. e., it sets. This takes place very rapidly.

In general, the higher the temperature at which it has been calcined, the less readily it sets. Gypsum calcined at over 200 degrees C. has all of the water of crystallization driven off, and recombines with water only very slowly, being consequently of no value for casting.

The probable reason for this is that gypsum needs already crystallized nuclei on which to build in setting. When all of the water of crystallization is driven off these nuclei are absent. Witness the fact that a handful of hydrated gypsum thrown into a cast very materially accelerates setting.

(4) Sodium silicate accelerates setting.

(5) Carbonate of magnesia retards setting.

(6) Gypsum with some soap solutions, forms an insoluble compound.

(7) For use as a wall plaster, gypsum is mixed with fine sand, and sometimes with fibre; being sold in this form under various trade names.

(8) —For use in tile, floors and roofs, it is mixed with sawdust or planing mill chips to give it body. This is the only filler that has proved uniformly successful. The proportions are varied slightly to suit conditions, and usually run about 2 cubic feet of chips per 100 pounds of gypsum plaster. The gypsum and plaster being mixed dry first, and the water added. Great speed is necessary in mixing and pouring after wetting, to avoid the setting of the gypsum and gumming up the apparatus before the gypsum sets.

All molds, tools, etc., must be cleaned after each casting, to prevent premature setting of the next batch due to crystallized particles left from the old.

Forms can normally be removed within 15 minutes after casting.

(9) Cast gypsum tile thus mixed with chips vary greatly in weight, and may be anywhere from 50 to 90 pounds per cubic foot when dry. The amount of water used also has something to do with it; the large excess of water customarily used in mixing rendering the casting more porous and of lighter weight when dried. This porosity is also bad in increasing the ability to absorb water after drying. But without the use of the excess water, gypsum sets too quickly for convenient handling.

(10) Linseed oil, neat-foot oil, and several others, painted on to the forms before casting, prevent the gypsum from sticking to the forms, and render them easily cleaned. Several lubricating greases are also good.

(11) Gypsum blocks wet or dry have negligible tensile strength. Strength in sheer is extremely variable, depending on porosity, chips in mixture, etc.; it however may be depended on in well cast blocks in the above proportion with chips at not less than 50 pounds per square inch dry. Compressive strength under the above conditions as to mix and dryness, is about 50 pounds per square inch with a safety factor of 5. When saturated with water, this may be reduced to as low as 15 pounds, with the same safety factor, or about 75 pounds per square inch in ultimate strength.

(12) Gypsum should never be used under conditions exposed to the weather without some treatment. Its ready absorption of moisture, weakens it; and when frozen, causes it rapidly to disintegrate. It is also readily abraded.

(13) Mixed with some of the magnesium compounds, it is partially transformed into epsom salts, and is rendered practically useless as a structural material.

(14) Gypsum very slightly shrinks on setting, gripping tightly any reinforcement that may be used in it.

(15) Gypsum chip blocks are exceedingly elastic—far exceeding in this respect any other structural material.

(16) The heat conductivity of gypsum is about two-thirds of that of asbestos. I have no exact data at hand, but make the above statement from experiments conducted by Professor Ordway and published in the *Trans. A.S.M.E.* This is very low for a common structural material; and high heat insulation results from its use.

THINKING WITHOUT A BRAIN

THE usual view of psychologists and physiologists has been that thinking, *i.e.*, that effort of the brain which consists in the last analysis of association, is possible only to animals high enough in the scale to possess a brain—in other words, a central nervous system with one ganglion of superior development. Some remarkable experiments recently made at the Oceanographic Institute of Monaco, and described in the

Bulletin of that learned body, for August 17, 1920, indicate that the power of associating reflexes is not confined to animals with a central nervous system, but also exists in such humbler creatures as the Hermit Crab. This little creature, which has always excited a good deal of popular interest from its well-known habit of borrowing the discarded shell of a periwinkle, or some other univalve mollusc, to keep house in, was the subject of the experiments in question, the following résumé of which we find in the *Revue Gènérale de Science* (Paris) Jan. 15, 1921: The so-called responsive reaction of living creatures can be divided into two groups: Congenital reactions and acquired reactions; the former are those natural or simple reflexes which occur as a response to any stimulus of the senses, while the latter depend upon individual experience and represent *associated reflexes*, which are due to neuro-psychical reactions.

A *natural associated reflex* is produced when an external stimulus which hitherto had caused no reaction on the part of the organism, has been associated for a number of times with another stimulus possessing the power of occasioning the said reaction, and, therefore, acquires this power of excitation, even when the primary stimulus is lacking.

An *artificial associated reflex* is established when an experimenter purposely associates a stimulus with another stimulus capable of producing a given reaction of one sort or another, as of the muscles, the vaso-motor nerves, one or more of the glands of secretion, etc. In the beginning the artificial associated reflex is not differentiated; it is obtained in response to stimuli of different degrees of intensity, as, for instance, the varying shades of a single color; or to take another example, if the responsive action is on the part of the foot the organism responds at first to the associated stimulus with movements of other parts of the body also.

When the associated reflex has once been formed it can be gradually differentiated by a special method of associating the two concurrent stimuli: this method consists in always making use of the principal artificial stimulus, together with the direct stimulus which reinforces it; accessory stimuli are employed without reinforcement. If this method be carefully followed differentiations of a very high degree of precision can be obtained. In the case of a dog, for example, trying to respond to an auditory stimulus, the modification of the exciting sound by 1/4 to 1/7 of its tone is sufficient to suppress the established associated reflex.

If the associated reflex be repeated from time to time without an association with a direct reflex, the associated reflex will gradually be extinguished and will become generalized, *i.e.*, its special differentiation will disappear. It is also true that it is possible to suppress the associated reflex quite rapidly, by using a sort of artificial brake, so to speak; such a brake is formed by a new external stimulus which is made to operate simultaneously with the associated stimulus and without the action of the original direct stimulus. Or, again, such a brake may consist in an increase of the frequency of the stimulus, or, even by causing the natural stimulus to act at intervals too near each other.

The associated reflex destroyed by such means may, however, be "unbraked," *i.e.*, made operative once more by employing the method originally used for producing it, or merely by increasing the length of the interval between the stimuli.

When the associated reflex is motor in character, it can be differentiated in the case of color, for example, not only as regards different colors, but even with reference to shades of the same color. Or, again, different reactions of the skin to the stimulus of heat may be obtained according to the point at which the stimulus is applied.

Pawlow's researches with respect to the exciting of the salivary glands, led him to conclude that only the associated stimulus is connected with the centers found in the gray matter of the brain and that the responsive reaction to this associated stimuli (*i.e.*, the flow of saliva) is independent thereof. Furthermore, he denies the existence of secretory centers in the gray matter of the cerebrum.

Bechterew's studies of the dorsal flexion of the foot, on the other hand, appear to prove that the responsive motor reaction and its localization result directly from the activity of centers in the cerebral matter.

MIKHAILOFF'S EXPERIMENTS WITH HERMIT CRABS

Mr. S. Mikhailoff of the *Oceanographic Institute* at Monaco, has recently made experiments along similar lines, except that he has endeavored to establish an *artificial reflex in invertebrate creatures*, which, according to general opinion, lack a central nervous system and, consequently, possess no brain. His researches had as their object the answering of the question as to whether neuro-psychical activity, *i.e.*, thinking, is possible without a brain.

His first series of experiments was made with an ordinary hermit crab, *Pagurus striatus*. Single specimens of this crab were placed in each of several glass aquariums, containing running water, and covered with a light wooden box, having on one side shutters containing screens of different colors, and on the opposite side an observation window.

Three principal reactions are observable in the hermit crab:

1. If one touches it, it retires into its shell.
2. If food is offered it, it moves forward and spreads its "pinchers," at the same time rearing itself on its hind claws, and makes an attempt to seize the object offered.
3. If it be turned upside down it comes out of its shell and then resumes its normal position.

The first step in the experiments was to accustom the crab to remain for some little time with its shell turned upside down. In this position the simple reflex is easy to obtain in response to the stimulus of touch, which causes it to withdraw into its shell. The next step was to associate with the tactile sensation (caused by touching it with an iron wire) red light passing through the screen in the open shutter. This was repeated every thirty seconds and 30 to 100 experiments per day were made. The associated reflex was found to be acquired with comparative stability at from the 8th to the 10th day, so that the crabs retired into their shells at the mere sight of the red light, and they repeated this action more than ten times on end without having the stimulus reinforced and as much as 25 times, if the interval between the stimuli was increased. Furthermore, the reflex was quite well differentiated, since the animal refused to respond to anything except the color which was the "educating" stimulus, even when shades of red very near this were employed.

After having obtained a series of associated reflexes which finally end in the extinction of the reflex, it is only necessary to reinforce it two or three times by means of the tactile stimulus, to cause the reappearance of the associated reflex and to re-establish a series of differentiated associated reflexes.

Upon the 36th day after the formation of the reflex and the 26th day since the beginning of its slow extinction, results were obtained which showed that the associated reflex was still both differentiated and stable.

SUMMARY

These experiments definitely prove that a complex neuro-psychical activity is possible in animals having neither a cerebrum nor even a central nervous system. In the case of man, however, the power to distinguish differences between colors and their shades is located in the gray matter of the cerebrum.

The following facts may be regarded as having been fully established by the experiments in question:

1. It is a mistake to compare the ganglional nervous system of invertebrate animals to the sympathetic system of vertebrate animals.

2. These methods enable us to study the functions of the various parts of the nervous system by "cutting out" after having established an associated reflex, one of these parts and studying the influence of this upon the associated reflex. It is possible to establish an associated reflex in response to any external stimulus whatever.

The Manufacture of Artificial Leather

The Raw Materials, the Processes and the Machinery of an Industry of Recent Growth

By Ismar Ginsberg

ARTIFICIAL leather may be defined as a material which has as far as possible the color, grain and external appearance of real leather, and which, because of certain properties of flexibility, resistance to wear and tear and ease of working, can supplant leather in many of its applications. A great many artificial leather products have been made and are on the market at the present time some of which resemble in no way whatsoever the material that they are intended to replace neither in their appearance nor in their properties nor in their cost. Moreover, even the best of the artificial products can hardly approach real leather in elasticity, flexibility, resistance to wear and tear, and permeability.

In spite of this, the interest in artificial leather at the present time is very great, for it is hardly conceivable that all the numerous articles that are made from leather substitutes, such as traveling bags, footwear of various sorts, book bindings, seats of chairs and other furniture, automobile finishings, etc., etc., could possibly be made out of real leather. There is certainly not enough leather produced to supply all our wants. This subject is therefore of importance to all, for we ought to know just what this substance is that we sometimes buy under the misapprehension that it originally came from the cow or calf.

THE CLASSIFICATION OF THE PROCESSES OF MAKING ARTIFICIAL LEATHER

Although the processes of manufacturing artificial leather are numbered by the thousands from the standpoint of the various materials entering into the compositions, nevertheless all these processes can be classified into two classes. The first general method of manufacture resembles that used in the making of oilcloth. This consists in applying an undercoat of an initial coating to a supporting background made of jute fabric or other animal or vegetable fibers. This undercoat has the property of making the fabric comparatively rigid, while in no way detracting from its flexibility and at the same time it acts as a close and solid tie between the final coats that are to be applied later and the underlying support. After a sufficient number of other coats have been applied the impression or the grain of the particular kind of leather that it is desired to imitate is pressed into the top coat by the aid of calenders of special process.

The second general method of manufacture is based on the principle of making kamptulicum, the forerunner of linoleum. This consists in grinding different substances to the proper state of fineness and in binding them together by the aid of suitable binding agents by pressing the composition in appropriate molds to form layers of varying thickness and homogeneity according to the uses to which the products are going to be put.

RAW MATERIALS USED

One of the principal raw materials used for the purpose of making artificial leather is leather refuse of all sorts, either reduced into the state of a powder or in the form of sufficiently fine scrapings. Leather refuse is in itself a high grade raw product for use in making these products, and very often it is replaced by paper refuse, old pasteboard, hay, straw, wood pulp, etc. The agglutinants used are strong solutions of rubber or resins, linseed oil or varnishes with a linseed oil base or any of the other drying oils, solutions of nitro-cellulose or cellulose acetate. These binding agents have the additional function of conferring the property of impermeability and waterproofing on the finished product. In the manufacture of artificial leather to be used especially for the making of shoes, mixtures are made with tarry or pitchy bases containing silicate of soda or other silicates and various filling materials.

Compositions containing as bases agglutinants which are originally soluble in water, such as casein, strong glue, gelatine, etc., when rendered insoluble by the well-known methods (such as by the use of formalin, etc.), have no practical use. In fact there is no real insolubility and the mass immediately swells up and absorbs water. In this condition it is no longer cohesive in any way nor does it possess any resistive powers.

In general, no matter what method is used, the manufacture of artificial leather requires quite a costly installation, which resembles very much that used in the linoleum industry. (For details of the apparatus used, etc., see *Rev. Chem. Indust.*, October, 1911).

THE USE OF PAPER WASTE IN ARTIFICIAL LEATHER COMPOSITIONS

The idea of using paper waste for this purpose is an old one and during the past war it was resurrected in Germany with some degree of success. Kummer, in 1830, originally proposed the use of this raw material. His method was to mix paper or other vegetable waste together with drying oils or resinous varnishes, adding a little iron filings or fine sand, and to subject the mixture to great pressure. It was claimed that the shoes made from this substance were very resistant to water and as strong as real leather shoes.

Unfortunately, actual usage proved the contrary to be true and this holds good with varying degrees of certainty for all artificial leathers made from a paper base. The trouble is that the drying oils which are supposed to render the product impermeable to water are not themselves resistant to water. They generally absorb it and the result is that shortly afterward the leather product loses its cohesive properties and just falls to pieces. If it is desired to remedy the porosity then it is necessary to dry the product at a high temperature, but this only results in making the coating very brittle. Brittle leather, of course, soon cracks and tears. Its life is very short.

The resinous compositions are much more resistant to water than the others, and especially so when nitrocellulose is mixed with them. The nitrated mixture is obtained by soaking, then removing the fibers from the paper waste, drying them rapidly and mixing them with a solution of cellulose nitrate or cellulose acetate and rosin. The composition is then pressed at a very high pressure. The addition of a little castor oil lends flexibility to the mass, while in no way harming the resistivity of the composition to water. Nevertheless the product that is obtained does not bear any resemblance to real leather.

THE BEST LEATHER IMITATION

The imitation leather that looks most like the real thing is made in the manner similar to that in which linoleum or oil cloths are made. It does not make any difference what the material is that constitutes the underlying support, be it either cotton cloth or linen, jute, or hemp, or even silk or wool or simply isolated fibers or paper itself, it is only necessary to see that either the back or the front or both is covered completely with the coating in order to obtain a good product. The determinant factor in the quality of the finished product is the nature of the coatings and the way in which they are applied.

THE HISTORY OF THE INDUSTRY AND THE PROCESSES USED

(There are so many processes and the development of the industry has been so great that it would be impractical to

detail all the various steps in the history and describe all the methods of manufacture. Only the more important facts will be given here. For complete detail the reader is referred to an article occurring in *Revue de Chimie Industrielle*, 30, 7-11, 35-40.)

It is claimed that the first manufacture of artificial leather was carried out in Germany. This was merely a composition of matter with a glue base. The use of textile backgrounds developed soon afterward. Almost from the very outset the leather dust and refuse collected from tanneries and factories where leather articles were made was used in compounding mixtures for the manufacture of artificial leather. The first agglutinants used were rubber and the various resins. Afterward rubber was replaced by boiled linseed oil.

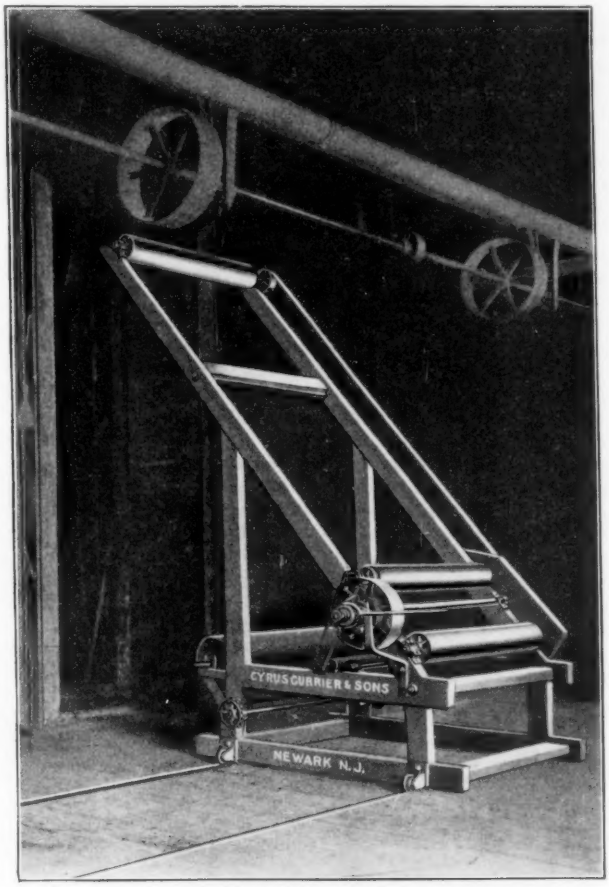


FIG. 1. THE MACHINE USED FOR COATING ARTIFICIAL LEATHER

Winkler has produced a material that resembles leather very much and which is used for the manufacture of gloves, gaiters and caps for containers. His process consists in coating fabrics with a composition containing rubber, glycerine and mineral substances. By passing the fabric through carding cylinders a certain degree of porosity is given to it.

The Pantasote Leather Co. manufactures a product used as a leather substitute which consists of four superimposed layers, viz., a bottom layer of coarse fabric, a thick solution of rubber, a fine fabric and a thin fluid solution of rubber. The entire product is compressed in such a manner that the designs or grain is not reproduced in the coarse material forming the background.

THE USE OF ALBUMEN AND SIMILAR SUBSTANCES

Many processes are known in which albumen, casein, gelatine and similar substances are used. In these compositions it is customary to cause the albuminous coatings to coagulate by means of treatment with ammoniacal or alkaline tannic acid solutions. The coagulated coating is then covered with a layer of rubber dissolved in various solvents, such as turpentine, benzine, etc. The final coat consists of a solution of soluble cotton or collodion. In order to gain flexibility molasses, glycerine or more often castor oil are added.

RUBBER COMPOSITIONS

An artificial leather has been made from a pasty mixture of leather refuse ground up very fine and mixed with a solution of rubber. The mixture is applied to the fabric body in the form of sheets which are pressed into the cloth in a special calender roll. India rubber, gutta percha or balata solutions are also used for impregnating fabric woven from a mixture of animal and vegetable fibers. After impregnation the rubber is thrown out of its solution by suitable means and forms an even layer over the fabric background. In another process balata rubber is dissolved in toluene to which dextrine, glycerine, gelatine and a small quantity of sodium carbonate are added. The very viscous mixture that is obtained is worked into ramie fibers.

FINELY DIVIDED METALS

There is an interesting process for making artificial leather in which a vegetable oil is used mixed with substances which are soluble in the oil and with finely ground metals such as aluminum, copper, iron, brass, etc.

ARTIFICIAL LEATHER WITH A CELLULOSE XANTHATE BASE

Artificial leathers made from a cellulose xanthate base are useful for certain purposes where it is not necessary that the product be very resistant to wear or possess great strength.

The textile support is made by felting an animal fiber cloth or cotton on both sides. Then the felted cloth is covered with a coating of cellulose xanthate by passing the same through a solution of the material. This coating is then covered in its turn with a coating of rubber or gutta-percha.

The felting is a very important operation and on the effectiveness with which it is carried depends to a great extent the quality of the finished product. Inasmuch as animal fibers lend themselves more readily to this operation, they are used preferably as the supporting fabric, even though they are more expensive than the vegetable fibers, such as cotton.

The solution of cellulose xanthate is prepared in the following manner: Cotton wastes are macerated in a solution of caustic soda, containing about 15 per cent NaOH. About a third of the solution is then removed and then about 40 per cent of carbon disulfide is added, figured on the weight of the cotton. The process is then continued in an autoclave until the mass becomes soluble in water. Enough water is added to give a solution of the desired concentration. To this solution castor oil, soap and coloring matters are added and it is then ready for use.

The impregnation of the felted cloth is carried on in practice by the help of a slight vacuum. This can be done in two ways. The vacuum can be attained directly in the impregnating vat by the use of a suction pump and the cloth in this manner is impregnated with the xanthate solution as soon as it enters the bath. Another way is to heat the rolled cloth strongly and make it pass over a drum which is heated with steam and then have it immediately dipped into a solution of the cellulose xanthate. After the cloth has been impregnated it is dried while being subjected to a slight tension by stretching the same between fixed supports. The next operation after drying is the washing of the product by passing it through a tank of water and thereafter through a chamber where the xanthate of cellulose, entrained in the fibers of the cloth, is decomposed by means of superheated steam and the cellulose is fixed on the fiber. The alkaline salts which are formed during this process are removed by a further washing. When an artificial leather of considerable thickness is desired, the process is repeated

as many times as necessary, each operation being followed by an immersion from 6 to 8 hours in cold, running water. In this way a number of coats is formed on the cloth support until the finished product is thick enough.

After the proper thickness has been reached, the coated fabric is hung up to dry in long drying houses. When dry, it is passed through a bath containing a solution of 15 to 25 grams of rubber or 75 to 100 grams of gutta-percha in a liter

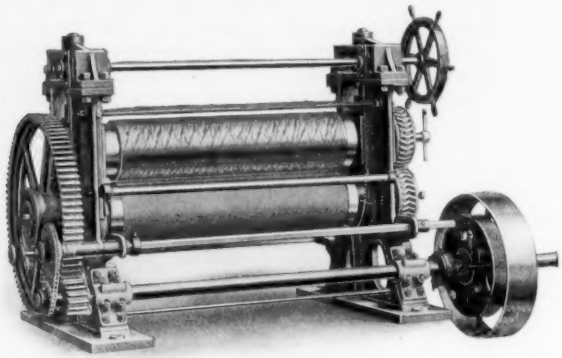


FIG. 2. TWO-ROLL EMBOSSING MACHINE

of carbon disulfide or benzine, mixed with a little gum damar for light colored leathers and with asphalt, rosin or stearin pitch for dark colored products. The quantity of the latter materials used varies from 2 to 10 grams per liter according to the rigidity or flexibility that it is desired to produce in the product. These properties however depend to a great extent on the concentration of the cellulose xanthate used in forming the undercoats and on the nature of the xanthate itself.

In drying the leather the solvents of the rubber may be recovered and reused. The artificial leather is then passed through embossed rolls which give it the grain of any animal of the sea, air or land.

WOOD FIBERS AS A BASE OF ARTIFICIAL LEATHER

It is well known that sulfite wood pulp can be molded very readily under pressure, but when the finished product is passed through calendering rolls, then it breaks at once and falls to pieces. This can be avoided by impregnatng the wood pulp with a solution of paraffine in light petroleum distillates. The material is then flattened between the rolls under a moderate pressure so as to avoid crushing the fiber. To guard against this happening the top roll is provided with springs which take up any excess pressure. As the strips of wood pulp pass through the rolls they are given a torsional motion. Then they are passed through the opposite direction to flatten out the twists. In this way a veritable molding together of the fibers is attained, which action is promoted to a considerable extent by heating the rolls by means of steam. The pulp is generally put through heated rolls as a final processing and receives a calendering treatment as well in order to increase the impermeability. This product is then used as a support for manufacturing artificial leather.

LEATHER CLOTH—NITROCELLULOSE BASE

There is hardly any question that the best artificial leathers are made from a cellulose nitrate base. There appear to be numerous processes which use this cellulose ester in various forms and in various ways. In one case a mixture of celluloid with cellulose acetate is used. A nitrocellulose soluble in an ether alcohol solution mixed with carob flour has been used, but this is of no real practical value.

The supporting fabric used in these processes may be of various sorts in accordance with the use to which the leather is going to be put. Generally for ordinary leather, such as is used in the upholstering of furniture or in covering the cushions of automobiles, there is used a cotton back of a high grade fiber in a dull blue shade. The cloth is woven very closely and is very strong and durable. The closeness of the weave is important in that it permits the first coat of nitrocotton to secure a firm grasp on the cloth and also does not permit it to penetrate the fiber and smear up the back of the fabric. Felted cloths are also used in cases where a fancy product is required or where it is desired to make a very thick leather.

The principal raw material used in these processes is cellulose nitrate or nitrocellulose, as it is generally called. Cotton is nitrated not only for the purpose of making smokeless powder and gun-cotton, but also for use in the manufacture of celluloid and artificial leather and lacquers. In each case the degree of nitration that the cotton is subjected to is fixed between definite limits as the properties of the nitrate vary very considerably with the amount of nitrogen that it contains. The nitro-cotton that is employed in making leather must contain in the neighborhood of 12 per cent nitrogen. The type of product that is very well suited for making celluloid is altogether unsuited for artificial leather and so it is with all the others. It is remarkable that the principal reason for this great variance in the properties of the nitro-cotton is the nitrogen content of the same. Just a few tenths of a per cent of nitrogen in the cotton makes a very considerable difference in its solubility in various solvents and hence in the uses to which it can be put.

It is aimed in the manufacture of artificial leather to use as soluble a nitro-cotton as possible. The higher the nitration of the cotton the more fluid it becomes, that is the more soluble it becomes in the various mixed solvents that are used in the manufacture of the leather. Solubility in this case means the extent to which the nitro-cotton will dissolve in a gallon of mixed solvents and still give a mixture which will be able to be worked within the artificial leather machines. Some cottons are more soluble than others, and generally the more soluble the cotton the more expensive it is, as the more it costs to manufacture because of increased acid consumption and the less the yield of the nitrated product from the cotton linters used to make it.

The nitro-cotton is dissolved in a mixture of volatile solvents. The proper selection of this mixture and the proper admixture of non-solvents is a very important technical detail

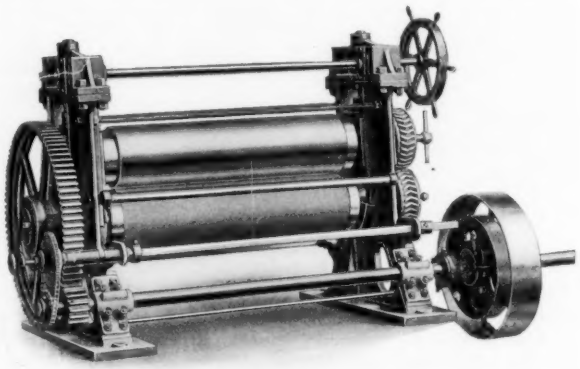


FIG. 3. EMBOSSING MACHINE OF THREE ROLLS, THE ENGRAVED ONE IN THE CENTER

in the artificial leather manufacture and has a very great bearing on the final cost of the finished product. In making the leather all of the volatile solvents and non-solvents are lost by evaporation, unless there is an adjunct solvent recovery plant in which the evaporated vapors are caught and condensed or absorbed in proper absorbents, recovered and rectified for reuse. This expedient has not been adopted to any great extent as yet in the industry. The solvents, viz., acetone,

ethyl acetate, light acetone oils, methyl ethyl ketone, etc., are generally much more expensive than the non-solvents, such as benzol and wood alcohol or denatured alcohol. Hence it is very desirable to keep down the proportion of the solvents used as far as possible, and at the same time have enough of the nitrocellulose dissolved in the working mixture to give a coating of nitro-cotton of the proper thickness and tenacity. This is another reason why it is very important that the nitrocellulose be as soluble as possible in the solvents to start with. In making up the mixture of solvents and non-solvents the aim of the manufacturer is to obtain as cheap and as effective a mixture as possible. Cheapness is procured by using much benzol, but too much cannot be used or else not enough of the nitrocellulose will be dissolved. Too little solvent will be just as costly in the long run as too little non-solvent. The mixture of solvents contains as a general rule about one part by volume of ethyl acetate or any other active solvent, two parts by volume of denatured alcohol and three parts by volume of benzene. The addition of the benzene to the solvent ethyl acetate, for example, decreases its solvent action very considerably, while the effect of the addition of alcohol is not so marked in the same respect. It appears that the alcohol is on the border line of being a solvent of the nitro-cotton and therefore its use does not cut down the solubility of the solvent too far. Sometimes just benzol and ethyl acetate are used, 30 per cent of the former and 70 per cent of the latter.

Various oils and pigments and fillers are mixed with the nitrocellulose solutions to produce different finishes and colors. Castor oil is used to give the leather its flexibility. The oil may be partially oxidized or not, but it is found that the oxidized product will give the best results.

The solution of nitrocellulose is tested for its viscosity in order to be able to tell whether or not it will be workable in the machines. The test is made by observing the fall of a steel ball bearing of definite dimensions through a fixed distance, usually ten inches, within a glass cylinder, whose dimensions are also standardized, at the room temperature. The temperature is important for the viscosity decreases rapidly as the latter increases. In the industry a limit of viscosity is set beyond which the machines will not handle the solutions. The main difficulty is to obtain the working viscosity and still have sufficient of the nitro-cotton in solution to give the proper thickness and quality of coating. This is the reason why it is not practical to dissolve celluloid scrap and old moving picture films in a gallon of the solvents and use the solution as such. These substances cannot be used as primary materials in the manufacture of leather. Another reason why this cannot be done is because they do not give films which have the proper tensile or tearing strength. The leather, made with them, does not possess very great resistance to wear and a piece of furniture covered with this product would soon wear through. The celluloid scrap and moving picture film scrap are used in admixture with the regular nitro-cotton and even at that they give a product of inferior grade.

The machines that are used to coat the fabric are arranged so that one or more coats can be applied at a time. The solution of nitro-cotton is pumped over the unrolling cloth in a continuous stream, the excess running off the cloth and being collected in a suitable receiver and repumped in the same manner. The apparatus is all enclosed so that evaporation of the solvents is prevented as much as possible. As the solvents do evaporate the solutions become thicker and thicker, and consequently the original solution must be fluid enough to allow for a certain amount of thickening taking place during the progress of the manufacturing process. All leathers are made in more than one coating. There is a general relation between the thickness of the film, the viscosity of the solution, the percentage of nitrocellulose that it contains, the percentage of film scrap and other nitro-cotton substitutes in the mixture, the cost of the nitrocellulose, the cost of the labor and material, including solvents, in making a coating and the number of coatings that the finished product must possess. The successful manufacturer strikes a happy medium between all these simultaneously variable factors which gives him the cheapest product of the best quality.

In manufacturing the leather the first coat contains no oil or pigment of any kind, but only the pure nitrocellulose. This coat is perhaps the most important of all, as all the others are connected to the fabric background through it and if it does not adhere to the fabric firmly and tenaciously, then the entire film covering of the leather will be held but loosely to the fabric support. Consequently, great care is taken to see that this initial coat adheres tightly to the fabric support and to increase its tenaciousness the oils and pigments are omitted from it. The solution however must not be too thin or else it will penetrate through the fabric and smear up the back, giving a faulty product, but it must neither be too thick, or else the proper degree of adhesion to the cloth is not attained.

After this coat has been dried, then the next coat is put on. The theory of the operation is that the solvent in the second coat cuts the surface of the first coat and effects a true union with it in this manner. This is then dried and the filler coats are put on in the required number to give the desired thickness

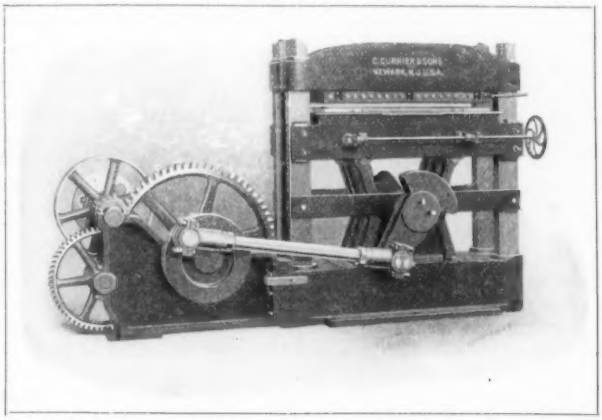


FIG. 4. EMBOSSING PRESS SOMETIMES USED IN PLACE OF THE ROLL MACHINES

of the leather. These filler coats are just what their name indicates. They generally do not contain very much nitrocellulose and can be made from film scrap, celluloid scrap, various gums, resins, clays, etc. These films do not have to possess the same degree of strength as the other coats. Then the final coat is put on and generally the leather is grained after this is done. The last operation is to put on the grained leather a thin coating of collodion cotton, which is very resistive to wear, and must necessarily be so, as it forms the coat which comes in direct contact with surfaces foreign to the leather and which rub against it and tend gradually to wear it down. The finish given to the leather can be varied to suit the purpose to which it is going to be put. Some leathers have a very lustrous appearance, others are very dull and still others are of a medium appearance. There is generally mixed with the solution last used some substance which will give the artificial leather the odor of real leather. Such a solution may be a concoction made by boiling up leather dust or may be obtained by the use of tannins.

Fig. 1 illustrates the type of machine used for coating artificial leather. It is called a coating machine. There are generally several of these machines in an artificial leather plant so that the application of many coats to the fabric background may be facilitated as much as possible. This machine stands in working position before the hot room where the coated leather is dried. The roll of fabric unwinds and

the cloth passes over a drum. Before it reaches that point it has received a coat of dope and the knife has scraped off all the excess dope that remains on the cloth. The dope, which has been mixed in the regular type of mixing machines is fed to the fabric through a nozzle which is placed somewhat in front of the knife. The coated fabric passes under one pulley and over the machine and another pulley on to the festooning device. There fingers catch hold of the cloth at certain definite intervals and carry it into the hot room. The artificial leather is strung from ceiling to floor, hanging in loop after loop, for drying, which is accomplished by means of steam coils. When the leather is dry, it is removed from the hot room and passed through the coating machine again to be given another coat of dope. After it has received the sufficient number of coats, it is ready for the embossing rolls.

There are two types of machines that are used for this purpose. One is the embossing rolls and the other, the embossing press. The embossing roll machines are shown in Figs 2 and 3. The first cut shows a two-roll machine and the latter a three-roll machine. In Fig. 2 the engraved roll is designated above and the counter roll below. The former is made of hammered steel while the latter is made of specially manufactured paper pressed on steel mandrils. The leather is passed between the two rolls and receives the impression of the design that is embossed on the steel roll. The paper counter roll serves to take up the compressive action of the steel roll against the coated fabric, which would otherwise be torn or injured in its passage through the machine. In the three-roll machine the engraved roll is situated between the two paper counter rolls. These machines are made smaller than the two-roll machines and are used on small widths of leather and in making special grades. These types of machines have arrangements for winding and unwinding the rolls of coated fabrics. The action of the embossing machines is to give the artificial leather the appearance of real grain leather.

The embossing press is shown in Fig. 4. The engraved plate and the counterplate are caused to come together with a certain degree of pressure or rather to within a certain degree of contact by means of a connecting rod-crank arrangement. The machine will emboss about 18 inches of leather at a time. The feeding of the leather into the machine and its removal after embossing has taken place is an automatic action which is synchronized with the raising and lowering of the bed plate. This type of machine is not as rapid as the roll embossing machines, but possesses certain important advantages over the latter. It is possible to obtain a grain which resembles the real leather more exactly with the press than with the rolls. The reason for this is that while the rolls are engraved from pictures of the real leather grain or for that matter from the leather itself by reproduction in a drawing, the plates in the press are made directly from the leather itself by an electroplating process. All the peculiarities of the leather are produced in this way and a product is obtained which defies detection. Another advantage lies in the fact that the adjusting of the machine is very much easier than in the case of the roll embossers. When a seam in the leather is reached, that is where one end has been joined together with the beginning of another roll, the roll machine has to be stopped and the rolls readjusted to take the seam. Otherwise if the seam was not of the same thickness as the piece of leather that has passed through the leather is apt to be torn by the rolls. In the press such exact adjustment is not necessary. The press is stopped and the seam is passed through the same without being embossed. Then the press continues operating. The leather cloth shows a distance of about one inch on either side of the seam which is unembossed.

THE CHEMISTRY OF THE THYROID GLAND

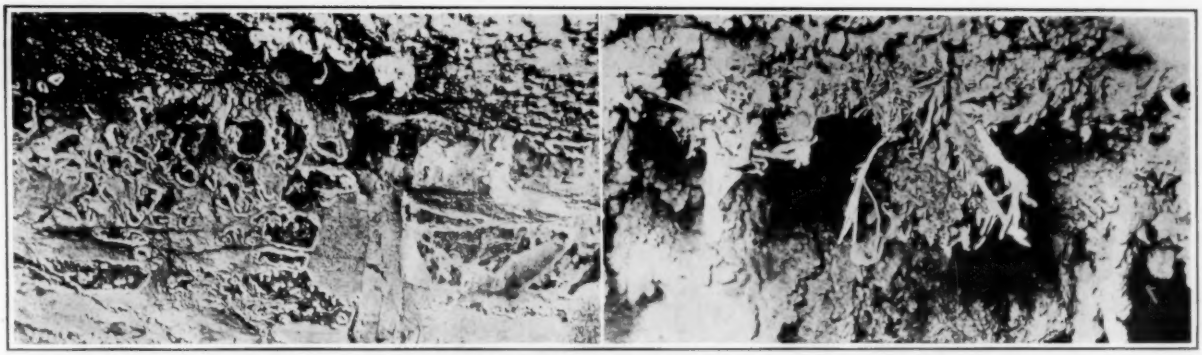
THE thyroid gland is now recognized to be one of the most important organs in the entire body. Situated in the neck in front and to one side of the larynx, it consists of two, round, lateral lobes, connected by a sort of "isthmus." It is covered with a characteristic form of epithelium and filled with a slimy mass—the so-called "colloid." This body is secreted from the cells which surround it. It consists chiefly of an iodated aluminous body called iodo-thyreo-globulin or more briefly, thyriodine. This substance possesses the function of furthering the general processes of oxidation; it regulates the normal processes of growth and development.

The greatest need of this substance experienced by the organism is during youth, when the processes of oxidation are most vigorous, and on this account the thyroid gland is much heavier in proportion to the weight of the body in children than in adults. Furthermore, we are justified in believing that the cells of the glands function more vigorously in the young. An enlargement of the thyroid gland consisting in a proliferation of the epithelium with a formation of follicles, as in the case of goitre, occurs when the thyroid gland in its natural size is incapable of furnishing the body with the amount it needs of thyriodine. This may take place whether there be provided a sufficient or an insufficient amount of the materials employed by the thyroid gland to form this substance. When an insufficient amount of the raw materials is furnished to the epithelium of the follicles, the epithelium is increased in amount to abstract the proper amount of raw material from the blood. This purpose is also served by a great increase in the blood vessels.

It appears that the thyroid gland always receives sufficient material for the formation of that component of the thyriodine known as globulin. But this is not the case with the other component iodine. In fact this chemical element is present in the blood in such minute quantities that it has hitherto been impossible to detect it by ordinary chemical methods. It is quite certain, however, that traces of it must circulate in the blood since there is no other way in which it could reach the thyroid gland. The amount of iodine in the blood depends chiefly upon that contained in the food of the individual, and this varies according to the locality. We may also take into consideration, perhaps, the traces of iodine found in the atmosphere along the seacoast and taken in through the lungs. In general the farther from the coast any sort of flora or fauna are found, the poorer they are in iodine. In any neighborhood where the inhabitants are free from goitre it will be found that the food supply is richer in iodine so that the thyroid gland obtains more of this element.

The most serious consequences of the formation of too small an amount of thyriodine in the thyroid gland are myxiedema cretanism and a "deaf and dumb" condition. These diseases do not usually take on an intensive character during youth because of the fact that during this period the over-development of the thyroid gland affords a certain amount of protection. But the thyroid gland of a person suffering from a goitre becomes senescent unusually early, and becomes subject to an extensive degree of atrophy. This atrophy sometimes causes a very considerable loss of weight in the gland. In this condition of advanced atrophy the gland is no longer able to furnish the organism with the necessary amount of thyriodine and the result of this is a still greater senescence.

The opposite condition to that of a decreased internal excretion of the thyroid gland follows those conditions in the body which accompany an intensification in the functioning of the thyroid gland; the most serious affection due to this cause is Basedow's disease. This malady presumably arises when the capacity of the cells of the body to form thyriodine is maintained to a greater age than usual. The cells form more thyriodine than is requisite for their normal functioning and this causes an irritated condition. The nervous symptoms which are prominent in Basedow's disease being the most obvious signs of it, have their cause in the lack of congruity between the amount of fixated thyriodine and the capacity for reaction of the nerve cells. Since this incongruity can never be very great in youth Baredow's disease is seldom found in children and only in a very mild form. It is not until after puberty that this disease appears frequently.



CHARACTERISTIC FORMATIONS IN KENTUCKY'S GREAT ONYX CAVE

Must Humanity Perish of Thirst?

The Possible Desiccation of the Earth Through the Depredations of Underground Watercourses

MUCH interest has been felt by men of science of late years with respect to what many of them believe to be the inevitable though, of course, very gradual desiccation of the earth which, of course, implies the eventual destruction of all life as we know it, since vital functions are impossible without moisture. This question has been discussed among others by such well-known men as Professor Lowell, Sir Archibald Geike, l'Abbé Moreux and the other French authorities, M. Haug and E. A. Martel. The latter authority has recently published an interesting treatise upon subterranean waters (*Nouveau Traité des eaux souterraines*, 8vo, 840 p. (Paris), Doin, April, 1921), one chapter of which is especially devoted to this subject. This chapter which is called *The Era of the Circulation of Subterranean Waters and the Desiccation of the Earth*, sets forth in detail the chief facts of our present knowledge of the waters whose course lies not upon but beneath the surface of the earth, dealing particularly with the results of the daring explorations which have been carried on for the last forty years or so, in the caves of Austria, France, Belgium, England, Spain, Italy, Switzerland, the Balkan Peninsula, the United States, etc. This chapter is, of course, too long to be reprinted here, but we give below an admirable abstract of it which appears in *La Nature* (Paris) for May 7, 1921.

The numerous facts which have come to light within the last 25 years have enabled us to form the opinion that the most ancient known phenomena relating to the circulation of underground waters and the effects produced by them upon the crust of the earth go back at least as far as the secondary epoch in geology. The late and much regretted geologist, Oehlert, was even of the opinion that in the vicinity of Laval certain carboniferous calcareous strata have been hollowed into pockets and gullies by the force and dissolving power of water before the coal age. As early as 1861 Delesse believed that the surface waters had already begun to diminish.

Many explorers, particularly Flamand, L. Gentil, Henri Hubert, Capt. Augiéras, etc., etc., have held the opinion that the dried up *oueds* or ravines of the Sahara carried great volumes of water in the Quaternary era.

De Lapparent thought that during that same era the bottom of the Grand Cañon in Colorado was filled with a much more powerful current than that of our time. This same view is held by W. Kilian with regard to the Guil of the Upper Alps and by David Martin with respect to the vicinity of Gap. The lowering of the level in the ancient lakes of Lahontan and Bonneville (the Great Salt Lake in the United States), the ancient river borders and fluvio-glacial terraces, the fossil thalwegs of the Cevenol Causses, the calcareous plateaus of Provence, the desiccation of certain regions in Africa, Central Asia, etc., have long been pointed to as signs of an increasing spread of dryness in the crust of the earth.

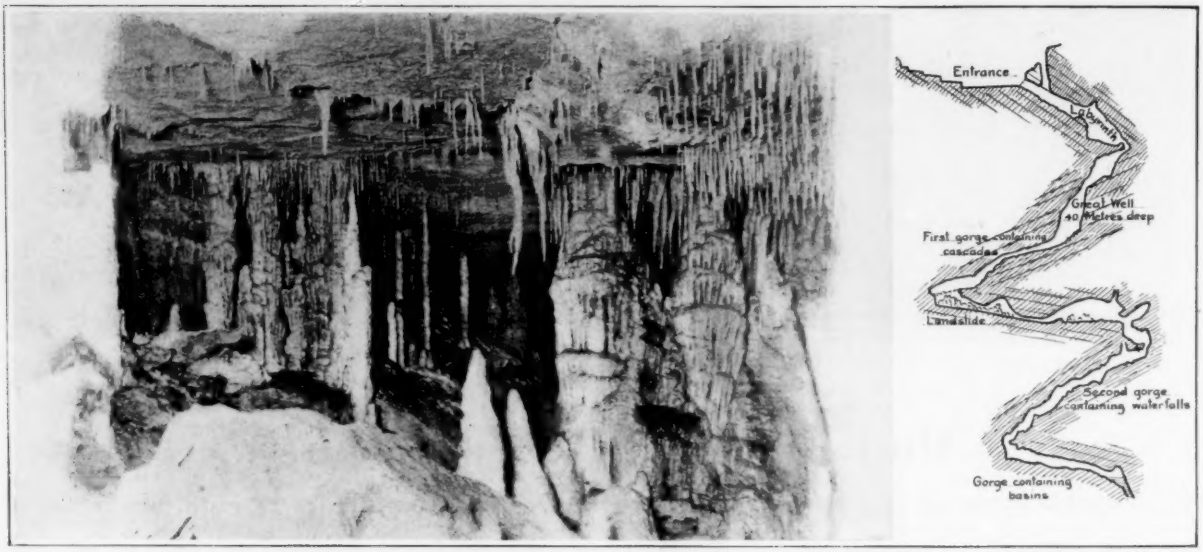
But most of all it is the recent researches in the interior of the ground itself which have "transformed from a hypothesis to a certainty the idea that the waters are gradually making their escape into the sub-soil or calcareous regions, and that there is a substitution among these lithological formations of a modern subterranean circulation for an ancient surface circulation." M. Martel enumerates and describes a great many very curious examples of the disappearance of springs, the deepening of subterranean rivers, the going dry of wells, etc., which make the future desiccation of our globe seem inevitable. He says "humanity must prepare for a fight with thirst."

One of the most convincing of the arguments offered to this effect is the perforation of the bottom of the upper galleries in caverns where subterranean rivers have dried up in the course of ages through an actual drawing off of their waters into profounder depths. This has been noted particularly in many of the caves among the Pyrenees during the researches made therein in 1908 and 1909 by M. Martel and his colleagues under the auspices of the French Bureau of Agriculture. Here there has even been mapped out the fossil subterranean course of the Traun (to the caverns of the Dachstein) which formerly flowed within the mountain at a level 1000 meters higher than that of today. In the Mammoth Cave of Kentucky, the largest cavern in the world (extending for 100 km.), the upper galleries are perforated repeatedly in this manner by great orifices through which their ancient waters have escaped.

It was not until 1916 that it was proved by M. Lahner, through his exploration of one of the two most profound abysses into which man has thus far ever succeeded in descending, the Sarcotic Grotto (315 meters) that the *polje* of Montenegro which lie at an altitude of 660 to 850 meters, are dried up.

Even under our very eyes we may see the capture of waters by the depths below in the losses to which the Danube and the Aach (in the Duchy of Baden are subject) still other examples of this loss of waters are found in many rivers of France. . . . The valley of the Nesque (Vaucluse) now loses on the top of Monieux (down river from Sault) its stream of water which is taken captive by the famous fountain of Vaucluse and it requires very violent storms to cause even a temporary flood to run in the bed of this superb dry ravine.

In the white chalk of Champagne and of Caux, a number of the outside thalwegs are quite dry and the water courses which once filled them must be sought beneath the earth (lower Seine, Marne, etc.) but while authorities agree pretty well with a few exceptions, as to the greater force exerted by



TWO SUBTERRANEAN WATERCOURSES, ONE IN PICTURE AND ONE IN DIAGRAM

Left: Ornamental columns in a Kentucky cave. *Right*: Plan of Montenegro's famous cavern, from the entrance 900 meters above the sea to the lowest point reached by exploration at 570 meters

streams of water in ancient geological eras, there is a lively dispute as to whether this process of desiccation has been actually manifested during historic times. . . . While a number of authorities agree that there is evidence of the "tangible visibility and rapidity of the phenomenon" in modern times, others hold that there has been no perceptible diminution of the waters upon the earth's surface during the period of historical record.

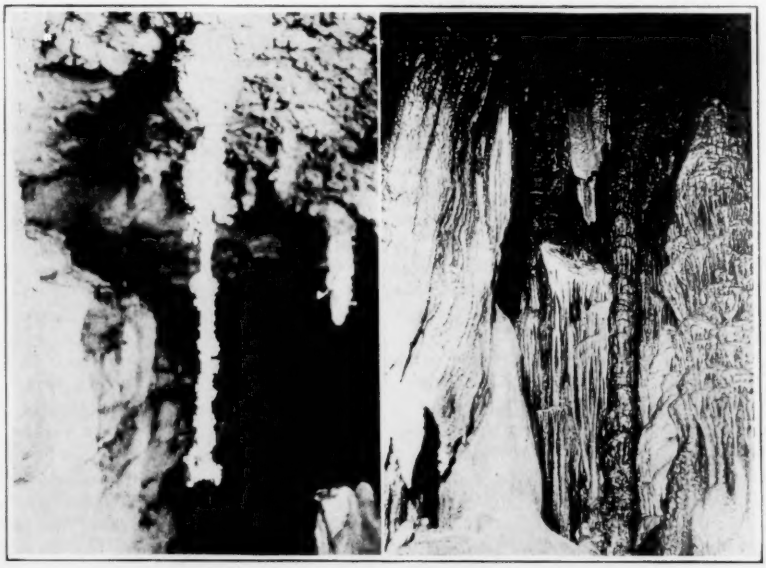
It is certainly difficult to form a positive conclusion in the matter in spite of the fact of a number of impressive cases of contemporaneous diminution in streams of water. We cannot be certain of the matter until after much further study and much more widespread observation.

Still another controversy rages as to the causes of the desiccation observed. Some geologists, including Martel and his school, ascribe it, at any rate in the case of calcareous territory, to the constant enlargement of the fissures in the subsoil, together with a decrease in the amount of water precipitated from the atmosphere. Still another school makes this last cause entirely responsible. Some writers upon this subject, such as Gregory and Haug, think that all the observed facts of the drying up process proceed only from regional changes in the distribution of rainfall, and thus remain purely local without assuming any universal character; others still, like Koenig, hold that there is a progressive desiccation of the earth's surface but declare that it is due to deforestation.

Still another group of observers believe that the phenomenon is due to the intensive agricultural cultivation of the soil, which diminishes the amount of water which would otherwise trickle into surface streams, together with the great increase in civilized countries in the number of ditches, roads, drainage canals, etc.

In a recent study of the matter presented to the French Academy of Sciences and published in the *Comptes Rendus* of that learned body for March 7, 1921, M. Chudeau sets forth his belief that the drying up of the desert of the Sahara, whose chief cause was the change of climate which took place at the end of the Glacial Period, has been completed by mechanical causes, such as tectonic movements of the earth and the barrages formed by dunes; he finds, however, that it is impossible to fix the date of the decay and disappearance of the former system of waters which supplied this area.

Apropos of the desert of Kalahari in South Africa, two studies were published by Schwarz in 1920, in which he attributes the drying up of this area to the capture of lakes or marshes by neighboring rivers; he expresses the opinion that suitable hydraulic systems would be capable of re-establishing the former condition of the country so as to make it once more habitable by man.



TWO MORE VIEWS FROM THE GREAT ONYX CAVE

The Chevalier and Tilho expeditions proved with respect to the variations in Lake Chad that while the drying up process is very slow and irregular it appears to be indubitable.

Svante Arrhenius, in a pamphlet published in 1919 entitled *The Light Course of the Planets* accepts it as a fact that there is a progressive desicca-

tion of the planet, but he ascribes this mainly to a decrease in the amount of carbon dioxide in the atmosphere, the CO_2 being little by little absorbed by the oxygen.

As for the astronomers and geophysicists such as Loewy, Armand Gautier, Emilie Belot, etc., they have long ago called attention to the fact that the moon, provided that it ever possessed any water must have absorbed it in its crust through a process of slow diffusion during the course of its cooling off. But here we touch upon transcendental hypotheses and it seems best to accept for the moment, at any rate, the practical conclusion thus expressed by M. Martel:

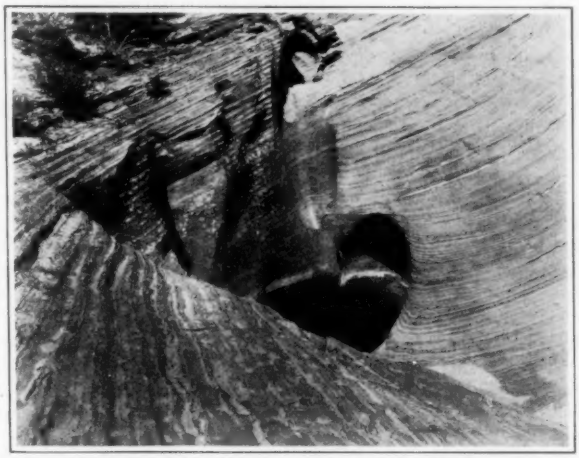
"To sum the matter up if it be still a debatable matter as to whether it is possible to discover in the atmosphere and in climates any diminution of the *historic degree* of atmospheric precipitation (which may be due to many factors), at any rate the three following statements appear to be practically incontestable:

"1. The reduction in the amount of running streams is pertinent to the matter, at least, since the Pleistocene geological era;

"2. The external erosion caused by water proceeds much faster than is generally believed, and it is even more rapid in the case of subterranean waters; and this in spite of their progressive diminution;

"3. The rapidity with which the gradual engulfing of waters within the crevices of the subsoil is carried on is more than sufficiently proved; this alone must lead us to the conclusion of the eventual complete desiccation of the crust of the earth. . . ."

So far as possible remedies are concerned, the most effective of all are reforestation, on the one hand, and an energetic fight against excessive and wasteful deforestation for industrial purposes on the other.



SUBTERRANEAN RIVER ENTRANCE IN THE ROCKY MOUNTAINS

THE MANUFACTURE OF CARBON PAPER

[*In a recent number of the Chèmischer Zeitung a description was given by Bruno Walther of the processes of making typewriter ribbons and typewriter inks. The development of the carbon paper industry practically parallels that of the ribbon and ink business and both are intimately connected with the typewriter itself. In the following article the manufacture of the inks used for making the carbon paper is discussed first and then the making of the paper itself.—Translator.*]

These inks must fulfil certain conditions in order to render the best service. These conditions are as follows:

(1) The inks must not penetrate through the papers which they impregnate. The back of the sheet of carbon paper must be free from smudges of ink that has leaked through and must present a uniform appearance throughout. When the thinness of a sheet of carbon paper is taken into consideration, it is evident that considerable skill is required to make the paper so as to fulfil this condition.

(2) The papers impregnated with these inks should give deep black copies, or if colored inks are used, brightly colored impressions. Inferior papers give grayish impressions which are hard to read especially when several copies are made at one time.

(3) The carbon paper ink should not rub off easily; in other words the paper should not smudge. On the other hand, the ink should yield its color readily, otherwise the pressure that would have to be applied to the keys of the typewriter would be inconveniently too great. This is an important point and it means that a happy medium must be sought for. The ink should not be so soft that it comes off too easily and smears up the copies and neither should it be too hard so that it is difficult to get any impression at all.

(4) The carbon paper should yield its color with the same ease or about the same facility even several years after it has been made as on the very day of its manufacture.

The manufacture of these inks has undergone a gradual development until at the present day its manufacture is practically scientifically correct. Formerly mixtures were brushed on the paper in the cold. These mixtures, for example, were constituted as follows: One kilogram of basic nigroine was dissolved in a mixture of 0.7 kilogram of olein and 0.3 kilogram of stearin. Then 5 kilograms of a solvent, such as benzol, toluol or zylol were added. In this manner a thick mass was produced which could be painted on paper with ease. The solvent evaporates quickly, leaving behind a coating of color mixed with olein and stearin. The paper impregnated in this way is made to pass over a hot plate, which produces a luster in the ink coating. To obtain colored inks various coloring matters, such as cerasin were mixed with the inks.

When the carbon paper is made by machines, that is when the impregnation of the inks is carried out mechanically, then certain changes are made in the composition of the inks. The solvent is omitted and the stearin is replaced by the olein, in which a large proportion of the oil color is dissolved. The process was entirely satisfactory, but with one exception which was sufficient to cause its abandonment. It was found that the olein penetrated the paper rapidly and made the back full of grease spots.

There are also inks of the type that is used for inking stamp pads. These inks are made with a glycerine base, but they cannot be employed to make carbon paper because of the hygroscopicity of the glycerine. Carbon papers made with them would soon absorb sufficient moisture from the air to be rendered completely useless.

At the present time carbon papers are made only by the process in which the paper is impregnated in the hot, for it is solely in this way that a product can be obtained that will fulfil all the conditions that were enumerated above. The essential point is the composition of the ink, which does not differ in principle very much from the inks that are used for the manufacture of typewriter ribbons. The process of making these inks is as follows: The pigments are ground in a cylinder grinder with oil. Paraffine or ceresine wax is added and then a basic color dissolved in olein. The grinding should be continued as long as possible so as to get a pigment of extreme fineness. A satisfactory test of the fineness of the grinding is afforded by smearing the pigment over a sheet of paper with the tip of the finger. A properly ground pigment will show an even streak of color on the paper; an improperly ground pigment will give smudge which will have light and dark spots.

The use of a cylinder machine which is capable of being heated simplifies the manufacture very greatly. In this case the paraffine or the ceresine wax is dissolved in a mineral oil and preferably in paraffine oil or liquid petroleum. The solution is made while heating gently. The pigment is worked into the mixture and the mass is ground, while the cylinders are kept at a temperature of 40 to 50 degrees Centigrade. At

the end of the grinding operation, the solution of the basic coloring matter is added to the ink still in the hot condition. The grinding is then repeated.

When just an ordinary machine is used, the sequence of the operation is modified. The pigment is first ground with the olein and then a part of the oil, containing the total quantity of the basic color, is added. Then the mass is ground again and mixed with a hot solution of paraffine containing the rest of the oil.

A formula which is used in the manufacture of a black ink is given below: Ten parts of lamp black of the best quality are ground in cylinder machines, with 40 parts of paraffine oil or mineral oil. Great care must be exercised in this operation. To this there is added 50 parts of a solution of basic nigrosine in olein, which contains one part of the dye to two parts of the oil. Then, the mixture is ground some more. The product is brought to a temperature of 40 to 50 degrees Centigrade and is then added to a molten mixture containing 40 parts of paraffine or ceresine wax to 30 parts of oil. After the constituents have been mixed together very thoroughly and carefully, the ink is ready for use in the impregnation of the paper.

In making colored inks it is often necessary to brighten the color by the addition of zinc white or other similar substances. The coloring matters are the same that are used in the manufacture of powdered inks, but when the Milori dyes are used there must be taken into account the fact that certain oils have the property of destroying their tints completely. Consequently it is very essential that the proper oil be selected for use with these colors. In order to brighten up the colors, there are added generally basic dyes dissolved in olein, such as nigrosine, methyl violet, Victoria blue, basic red, scarlet, etc.

It is also possible to make colored carbon paper without the use of any pigments at all by mixing together concentrated solutions of basic colors in olein with paraffine or ceresine wax dissolved in hot mineral oil. The following formula can serve as a standard method of accomplishing this: Ten parts of methyl violet (the base, not the salt) are dissolved in ten parts of olein, while the mixture is heated moderately. Then there is added thereto a molten mixture of 5 parts of ceresine wax and 5 parts of mineral oil. The whole mass is then mixed very thoroughly. It is true, however, that the inks that are made without the use of pigments are not as richly colored as those which include such coloring matters in their composition.

In making copying inks, instead of pigments various basic coloring matters, such as crystallized violet, safranine, methylene blue, etc., are used. These dyes are mixed with three times their weight in oil and then the mixture is ground in machines. While the mass is being agitated, a molten mixture of 1.5 parts of paraffine or ceresine wax in 1.5 parts of oil is added. Either the paraffine oil or the mineral oil can be replaced by a vegetable oil of good quality, such as rapeseed oil.

The quality of the impregnated paper is fixed by the quality of the original paper used. There is no such thing as a paper which is at one and the same time both tough, strong and thin, which can be used for this purpose. Of course it is realized that these are conditions that are obtained but very rarely in one paper. Carbon papers for copying can be made of thicker paper than the ordinary carbon paper.

The modern process consists in impregnating the paper in the hot condition. This is accomplished by the aid of a machine, which is built in the following manner: The paper is wound on a roll and is unwound therefrom and made to pass around a metallic cylinder, which itself turns in a bath of ink. The ink on this metallic cylinder is transferred on to the paper, coating it with an irregular thick coat. The trough of ink is heated by means of an oil bath or a sand bath, which keeps the temperature at a constant level and prevents the ink from burning. The thick uneven coat of ink on the paper is then scraped in such a way that the coating of ink is made uniform throughout. This operation is effected in the hot condition by causing the paper to wind around a cylinder heated internally. The small scraper that accomplishes this work is so arranged that it can be set at any required distance above the surface of the paper and it has an up and down motion, which is of considerable advantage when inky coatings are being treated which are exceedingly difficult to make uniform.

After the scraping operation the paper passes over a cylinder chilled with water. This causes a rapid setting of the inky coating to take place and makes it assume the glossy appearance that is so familiar. Frequently the paper is given still another treatment. It is wound around heated cylinders for the second time and the melted color is spread over it by the aid of two flat brushes which are set into motion by a reciprocating arrangement. In this manner papers are produced which have a zigzag coating. Then the paper is passed over chilled cylinders again.

The finished product is either rolled into rolls or it is cut up into sheets of various sizes. The packing in cartons is done in such a manner that the carbon paper is kept protected from dust. Very often carbon paper is required that has an uncoated border of one-eighth to a quarter of an inch. In order to make such papers, the machines are provided with an arrangement that removes the ink that is applied on the edge of the paper.

FORD'S POWER PLANT MAY BE ABOLISHED

THE enormous power plant at the Ford Highland Park Factory, long the pride of Henry Ford, is soon to be transformed from a gas-steam plant to an all steam plant, or is to be abolished entirely. Engineers, headed by Wm. B. Mayo, are now determining the most economic method of handling the power situation. The gas-steam plant has been in operation for over ten years and a point has been reached where gas-steam power is no longer as economical as steam power would be alone.

Two plans are under consideration. The first involves the junking of the producing gas plant and installation of additional steam boilers. This would cost approximately $2,000,000. The second plan is to eliminate the Highland Park power plant entirely and bring high tension power from the River Rouge, which would require an addition to the latter plant. This cost approximates $3,000,000.

There will be no interference with operations at the Highland Park plant while the power changes are under way. The Detroit Edison Co., which has a power house nearby, would furnish 90 per cent of the present peak power, which runs about 75,000 horsepower.—*Automotive Industries*, Vol. 45, No. 9, Sept. 1, 1921, p. 438.

THE ELECTRIFICATION OF THE AUSTRIAN STATE RAILWAYS

THE early extension of the electrification of this system has been decided upon mainly on account of the heavy cost of coal since water power averaging over 100,000 horsepower throughout the year is available at the Spullersee at Danöfen. The works were commenced late in 1919. The Spullersee hydro-electric station will be worked in conjunction with the similar station on the Ruetzbach. These two power stations when completed will be capable of supplying 64 million kilowatt-hours annually. The Ruetzbach station already supplies power for the electrified Mittenwald Railway and contains two generating sets, each of 4000 horsepower. This station is to be also used for supplying the section Innsbruck-Landeck-Bludenz, and for this purpose is to be extended by a generating set of 8000 horsepower. The Ruetz and Spullersee stations are to be connected by a 55,000-volt transmission line about 110 kilometers long. It is hoped that in 12 to 15 years all lines will be electrified.

Ammonia from Coal Distillation

The Significance of Recent German Experiments Looking to an Increased Yield

IN the year 1904, in a publication entitled "Coke Ovens and Their History" Dr. Paul J. Mallmann proved conclusively that the patents taken out by Otto, Hilgenstock and other German scientists for the distillation of coal and coal gases had been anticipated in the seventeenth and eighteenth centuries by English and Scotch scientists. What Otto and Hilgenstock did in the sixties and seventies of the last century, these British pioneers had thought out and patented at least a hundred years before; but unfortunately these British patents were permitted to lapse without in any way benefiting mankind. Between the years 1623 and 1868 practically all patents dealing with coal gas distillation bore British names, yet it appears that, with rare exceptions, not a single one was either exploited by the inventor himself or found financial support in England. Like Wm. Bessemer's discoveries—if for the time being we credit him with the discovery of the pneumatic principle and the pear-shaped furnace used by him for converting molten iron into steel—these had to go abroad to secure due recognition and financial support.

We are dealing again today with a German invention and practical application of discoveries made by British minds years before. In the year 1868 and again in the year 1874 J. C. Hills secured letters patent Nos. 1368 and 1934, respectively, to wash coal gas of its hydrogen sulfide contents, with a diluted ammonia solution, but it appears that Hills did not ascertain the precise temperature required at which the hydrogen sulfide contents of the gas is absorbed. According to his calculation six to seven times the quantity of ammonia was necessary for the elimination, whereas in fact double the quantity extracted from a ton of coal is sufficient to absorb all the hydrogen sulfide from coal. As J. G. O'Neill pointed out correctly in the year 1912, on page 868 of *Progressive Age*, it was due to this miscalculation that Hills' patent did not prove a commercial success.

Now O'Neill's process is in operation at the Gas Works at Geneva, in the State of New York, and due reference will be made to same in the course of this review. Here be it briefly stated that hydrogen sulfide, hydrogen cyanide, and some carbon dioxide are withdrawn from the coal gas by passing it through a weak solution of ammonia.

Generally speaking it has not been found to be a paying proposition, on account of the low prices paid for the commodity, to extract the hydrocyanic acid from coke-oven gas by installing the required cyanide washer, because the amount recovered is found to be insufficient even in the gas produced by the gas plant. It stands to reason that both to the by-product-recovery coke-oven plant and by inference to the gas plant, it would be a commercial advantage if that portion of the hydrocyanic acid now burned uselessly in the ovens could be cheaply converted into ammonia.

F. N. Sutton, in charge of the coke-oven plant of the Colliery Amalia at Werne, Westphalia, demonstrated in 1914 to the satisfaction of Carpenter and Linder, as is recorded in the *Journal of the Society of Chemical Industries*, page 584, Vol. 23, that the excess of ammonia gas was due to hydrocyanic acid occurring in the Claus furnace, which had been supplied with the off-gases of a gas-liquor utilization plant. There was shown a considerable excess in ammonia in the leaving gases over the entering gases, though the gas volume had been increased from 1 to 1½ by the air for combustion. The entering gases showed 1.955 grams of ammonia per cubic meter and the retiring gases 11.896 grams per 1.5 cubic meter; and Sutton argued correctly that this eightfold excess of ammonia could only be due to the presence of hydrocyanic acid, since the quantity of ammonia entering the furnace as a carbonate was far from sufficient to permit of any other explanation. Hydrocyanic acid forms ammonia with NaOH according to the equation

$$HCN + NaOH + H_2O = NH_3 + HCO_2Na;$$

and determination of the satiated gases as 20.149 grams and of the hydrocyanic acid as 12.739 grams per cubic meter showed that this quantity was quite sufficient to explain the ammonia formation. The correct conclusion was arrived at, that the ammonia was produced by the hydrocyanic acid and the gas vapors generated by the oxidation of hydrogen sulfide. Again it has been found that ammonia is produced when water vapors and hydrocyanic acid are conducted over catalyzers like chamotte iron oxides or weldon mud, if brought to a sufficiently high temperature; similar results were attained by Schreiber as narrated in the *Magazine of Applied Chemistry* of Nov. 8, 1912.

Profiting by these investigations Dr. Freidrich Sommer designed an installation which converts hydrocyanic acid into ammonia, thereby transferring a loss of the by-product-recovery coke-oven plant into a profit. The experiments conducted covered a considerable period of time, and are herewith briefly given in epitomized form, as well as a short description of the plant employed.

Hydrocyanic acid was liberated from a solution of potassium cyanide, the contents of which had been checked by volumetric analysis, by dripping sulfuric acid into a potassium solution. The hydrocyanic acid then liberated was heated with water vapors and led through three washing bottles. The best results were secured when sulfuric acid of 60 degrees Baumé was used. Twenty-five cubic centimeters of potassium cyanide solution, corresponding to 12.31 cubic centimeters of normal silver solution or equivalent to 24.7 cubic centimeters of normal ammonia, were brought to the boil with water in an Erlenmeyer, and then were decomposed by slowly adding through a dropping funnel 50 cubic centimeters of normal sulfuric acid. The hydrocyanic acid thus generated was led through 3 wash bottles each containing 25 cubic centimeters of sulfuric acid of 60 degrees Baumé. The hydrocyanic acid which was not changed into ammonia was collected in ammonia and liberated. The sulfuric acid contained in the wash bottles was diluted and the ammonia contents determined. The results of this test showed that an excess of water vapors and heating act favorably on the acid and up to 98.37 per cent of hydrocyanide was converted into ammonia. But since the hydrogen cyanide vapors when leaving the satiator are not only rarified with steam but also with carbon-dioxide gas, an experiment with an apparatus which could force a jet of carbon dioxide through the reaction vessels was made. The conversion into ammonia was slightly reduced, but was still satisfactory. By introducing the jet of carbon-dioxide slowly 95.95 per cent of the hydrogen cyanide was converted into ammonia, whereas by accelerating the flow of hydrocyanic acid the output in ammonia sank to 92.72 per cent.

The experiments were carried on with a large excess of steam, and the question arose whether a lesser steam content of the reaction mixture would advance or damage same. Consequently the further experiments that were carried on were conducted by satiating the gas at a temperature of 70 degrees Centigrade with steam, when it was conducted into the acid.

The generated hydrogen cyanide passed with the additionally introduced carbon-dioxide gas, and the vapors of water—corresponding to a satiation at the cooling temperature—through the three reaction bottles, where it was either dissolved or it passed with the carbon-dioxide gas into the enlargement tube, filled with ammonia, where the hydrocyanic acid not converted into ammonia was absorbed. The last wash bottle contained diluted sulfuric acid, so that the ammonia carried along from the spherical tube could be absorbed.

The dropping funnel was repeatedly rinsed out so that it

was certain that all potassium cyanide entered the decomposition flask. After the completion of the tests the absorbed non-decomposed hydrocyanic acid contained in the spherical tube was triturated with nitrate of silver, with potassium iodide as indicator; the contents of ammonia contained in the sulfuric acid was ascertained separately.

Experiment with carbon dioxide, also experiment with hydrogen addition gave good results; tests carried through at a low temperature of the reaction acid produced a large quantity of non-dissolved hydrogen cyanide, and even a loss, a finding which up to now had not appeared in any one of the previous examinations; further tests showed still greater losses in spite of higher reaction temperatures, and this proved that the loss was not due to a low reaction temperature. It was also found that the potassium cyanide solution had decomposed by forming cyanide combinations, and that it was impossible to generate from these combinations further hydrogen cyanide by adding diluted sulfuric acid.

As a consequence all other experiments were carried through with a new potassium cyanide solution; a very high conversion was attained without any loss, the speed of the gas being now measured by a gas meter. A gas meter of 28 liters' capacity was eventually added and the gas mixture for one test was found to be of the following composition by volume: Oxygen, 4.15; carbon dioxide, 8.45; methane, 2.55; hydrogen, 69.90; nitrogen, 14.95.

The experiments showed that a high output of ammonia could be obtained with the described installation, at a given temperature, and were now applied to an outfit adapted to the coke-oven by-product-recovery practice.

Of the direct processes, the one of Collins appeared the one most suited, for in this the hydrocyanic vapors emanating from the column apparatus enter the satiator independent of, and separated from the gas.

In the lowest plunger the vapors give up their ammonia contents and their excess of steam to the liquor, having given off a portion of their temperature to the inner partition, *i.e.*, the separation wall. The lye has a temperature of from 70 to 75 degrees Centigrade; in the four reaction chambers, the sulfuric acid meets the vapors having been raised by the vapors to a temperature of from 70 to 100 degrees, and converts the hydrocyanic acid into ammonia, bringing it to the lye bath. Even the old open satiators or the closed satiator of the Weldon type can be built into the hydrocyanic-acid recovery plant as an adjunct without any difficulty whatsoever.

It will be found profitable to increase the contents of the hydrocyanic acid found in the coke-oven gas water and Dr. Sommer achieves this end in the following manner:

He separates that portion of the vapors of the column apparatus emanating from the lower columns reserved for volatile ammonia, or alternatively separates the vapors of the lime column, eliminates the steam by means of a reflux cooler and conducts the ammonia vapors, practically free of CO_2 and H_2S, into the gas main before they enter the last cooler.

The small alteration required in the steam conduit of the separating plant makes itself well paid especially if dry coal is coked because the hydrogen sulfide and the hydrocyanic formations are materially increased and an increase in steam consumption does not take place.

A process to some extent similar to the one just described is the O'Neill process in operation at the Geneva Gas Works, at Geneva, N. Y. It tends however more to wash the gases of their hydrogen-sulfide contents and the process is mentioned in the year 1912 by the *Progressive Age*, on page 868, and by the *Journal for Gas Illumination*, on page 304 in the March issue of 1913.

It appears that this process increases considerably the steam consumption, and it would also appear that hydrogen-sulfide, carbon-dioxide and fixed ammonia are reintroduced into the gas water circulation—drawbacks which are avoided by introducing ammonia vapors from the lime columns; a procedure which does not demand an unnecessary steam consumption.

Hydrocyanic acid is recovered without difficulty by installing the satiator when dealing with old and indirect installations. And this is of particular importance to the gas works, for by so doing they obtain a considerable increase in their ammonia output on account of the relatively high cyanide contents of their gas water.

To establish this Dr. Sommer created similar conditions by leading a mixture of hydrocyanic acid and hydrogen gas into a three-necked bottle containing saturation lye, the temperature of which was kept at 70 degrees Centigrade by a thermostat before the mixture entered the flask holding the sulfuric acid, which was retained at a temperature of from 70 degrees to 100 degrees Centigrade. The liquor at 70 degrees Centigrade served here the purpose of a reflux cooler, since it absorbed the excess of steam; besides this, a strong current of air was forced through the lye, a procedure which corresponded with gas production practice, and carried with it also the steam.

Losses of hydrogen cyanide were sustained in some experiments because of the non-uniform pressure of the air entering and leaving, and also because of the flow of hydrogen cyanide mixed with hydrogen and steam, which could hardly ever, or only with great difficulty, be kept uniform. Consequently it could hardly be avoided, that temporarily hydrogen cyanide entered into the air chamber, through the central open dip pipe, open at the bottom; and this gave to the air passing through the air chamber its characteristic pungent smell.

Remarkable appeared the contents of carbon dioxide and methane in the gas of two experiments. It had to be ascertained whether this occurrence was due to the dissolution of the hydrocyanic acid, or to the hydrogen drawn from the steel container. The hydrogen of the supplying steel container was examined and was found to contain by volume hydrogen 95.65 per cent, oxygen 0.30, carbon monoxide 2.05, and nitrogen 2.00. Therefore, the methane could not have originated in the container. To eliminate the oxygen, the hydrogen gas was led through a porcelain tube, at a temperature of 1100 degrees Centigrade, and then led through liquor and soda lime to eliminate any possibly formed carbon-dioxide gas. Notwithstanding these precautions again methane was found; hence methane was formed during the reaction, namely, during the dissolution of formic acid, formed as intermediary product. To prove this assumption carbon monoxide was produced from formic acid. This gas was passed through soda lime to eliminate carbon-dioxide and acid vapors, and showed in analysis, by volume, methane, 2.05 per cent; hydrogen, 0.85; carbon monoxide, 94.10; oxygen, 0.60; and nitrogen, 2.40.

By this it is proved that methane can be generated in considerable quantities when formic acid is decomposed. This reaction will also take place in the method described, since the dissolution of hydrocyanic acid passes over the formic acid. The analysis of the experiments show carbon dioxide content. The hydrogen content of the carbon dioxide produced from the formic acid proved that formic acid is dissolved according to the following formula: $HCO.OH = CO_2 H_2$.

The conditions of the experiments with hydrogen cyanide gas are quite similar, and in such a way the reaction takes place; only one does not find the generated hydrogen gas because hydrogen has been added; on the other hand the equivalent amount of carbon dioxide gas makes itself observed.

From the last tests it is apparent that in practice also where steam charged with potassium cyanide has to pass through a sour sulfate liquor, far-reaching disintegration must take place. But it was not proven whether or not hydrogen was generated when hydrocyanic acid is saponified. Furthermore, it had to be ascertained whether the constantly found hydrogen sulfite advances the reaction. Carbon dioxide and hydrogen sulfite were passed through the outfit and it was shown that over and above the previously proven carbon dioxide and methane, hydrogen was also produced in considerable quantities through secondary reactions.

Now the tests were made with an addition of hydrogen sulfite. Since hydrogen sulfite produced from ferric sulfites is never free of hydrogen, the attempt was made to produce the hydrogen sulfite by acetating poly-sulfide of potassium. As the production of this gas by these means was found to be too uncertain a stream of carbon dioxide gas was passed through a heated, or through a cold concentrated solution of potassium sulfide, and this stream of carbon dioxide gas satiated itself with from 5 to 2 volume per cent of potassium sulfide. In this experiment the washing flask was used for the poly-sulfide of potassium, and the tilting apparatus was utilized for the generation of the carbon dioxide gas. A thinly drawn out glass tube to act as capillary was inserted in sequence before the tilting apparatus, which arrangement regulated the speed of the gas in all subsequent experiments. In the flask there was contained, as in previous experiments, normal sulfuric acid, in the dripping funnels a potassium cyanide solution. The gas was collected in the gas tank and then forced through an apparatus to free it of carbon dioxide gas and hydrogen sulfide, which it contained in large quantities.

The wash bottles and the gas collecting tubes were filled with a strong lye of potash; besides this the gas-collecting tubes contained some ferro-hydroxide to eliminate by absorption any remnant hydrocyanic acid. By water pressure the gas was forced from the gas tank through the worm of the washing bottle; and the carbon-dioxide gas as well as the hydrogen sulfide gas were absorbed. The gases which had not been absorbed collected in the upper portion of the wash bottle and entered, forcing the potash lye (liquor) before it, the upper portion of the first gas-collecting tube. After they had filled this tube they entered the next gas-collecting tube. More than 750 cubic centimeters of gas were never collected, excepting in one experiment when about treble that amount of gas was found to be present.

Prior to the gas being liberated from its absorbable constituents, an average sample was taken from the gas tank to ascertain the relation of the absorbable portion to the non-absorbable portion in lye of potash (liquor). When the test had been completed and the gas after repeated washings had been collected in the gas tank, about 0.95 liters were led through a small aspirator through acetate of cadmium, and the hydrogen sulfide contents ascertained.

Experiments carried through with an addition of hydrogen sulfide show that this addition acts favorably on the ammonia output, in so far as it damps the secondary and harmful reactions, which take place under the formation of methane and hydrogen.

CONCLUSION

It is claimed that hydrogen cyanide without steam or labor can be recovered as sulfate of ammonia by saponification of the hydrogen cyanide by means of sulfuric acid. Considering that a major portion of this is lost at present, and the installation is not expensive, trials at the gas works and at by-product-recovery coke-oven plant are worth while, but first exhaustive tests on the lines indicated should be made in the laboratory, with a view of simplifying the procedure.

POROUS METALS FOR STORAGE BATTERY PLATES

FOR certain purposes, in particular for the construction of storage-battery plates, it is desirable to employ metal in a porous state, since in this condition there is a comparatively large surface for a given weight of the metal. This is achieved by means of technique based upon the fact that alloys in process of solidification crystallize differently according to the temperature at which the operation is conducted and do not solidify abruptly at a given temperature, but solidify slowly and between temperatures which are separated from each other by intervals varying in extent according to the metals and their proportions which enter into the alloy. It might perhaps be expected that each constituent metal would "freeze" out of the mixture completely as its solidification temperature is attained; but this is not the way it works. The thing can better be illustrated by an example than described in general terms.

In an alloy composed of equal weights of lead and antimony solidification begins at 540 degrees Centigrade by the formation of crystals of antimony whose dimensions increase in proportion as the temperature decreases down to about 225 degrees. At this instant the still fluid mass consists of an alloy which is very different in proportions from the initial mixture, since it contains 87 per cent of lead and only 13 per cent of antimony. This is called a "eutectic" alloy; and its critical temperature of +225 degrees represents at once the point of fusion and a constant temperature of solidification. As soon as this temperature is reached in the course of cooling one observes the instantaneous solidification into a mass of the entire remainder of the liquid, and the appearance of a tangle of fine crystals of the two metals. However, so long as the temperature remains between the two extremes of solidification, 540 and +225 degrees, the ensemble retains its plasticity, since the crystals of antimony are immersed in the eutectic liquid. At the end of the operation the mass is composed of a network of comparatively large crystals enclosing canals of various size and configuration, which are filled with the tangled and much finer crystals of the eutectic alloy.

A Danish metallurgist named Hanover has conceived the idea of preventing these latter crystals from forming merely by expelling the liquid portion before it has attained its solidification temperature; and his method has been found advantageous in industry. To eliminate the remaining liquid it is only necessary to employ a non-oxidizing gas under pressure—for example, either carbon dioxide or nitrogen. Oil pressure is available here, or better still the liquid is expelled by centrifugation. The final porosity is a result of course, of the spaces left in the canal which were previously filled with the eutectic alloy. The degree of vacuity depends on the one hand upon the proportion of the metals in the original mixture, and on the other upon the temperature at which the liquid is expelled. Consequently, the degree of porosity can be controlled to a considerable extent, care being taken merely that the metal finally obtained after evacuation of the canals shall be sufficiently solid.

In practice it has been found that the higher the fusion points of the metals employed, the greater the difficulty of obtaining porous alloys; but this difficulty can be avoided by using the method outlined to obtain first a porous mass of lead, for instance, the spaces in which are then filled with metals which are not very fusible, such as copper, silver, etc. These are to be deposited by electrolytic means, and then the temperature can be raised to a point slightly above that of the fusion of lead, and the latter can be immediately expelled by centrifugation as soon as it becomes liquid. In this manner we obtain a porous mass whose cavities correspond to the solid portions of the previous mass and vice versa—in short, we have a sort of negative of the original porous mass.

By this ingenious method of operation the available surface of the sheets of lead can be made a hundredfold as great instead of scarcely tenfold as great as when the usual methods of undulation and perforation are employed. Thus the capacity of battery plates is very greatly increased, aside from the fact that it remains possible to increase the surface still more by the usual means of employing metallic oxide. It is only necessary in fact, to employe these substances to fill the cavities left by the expulsion of the eutectic alloys. However, since it is necessary to have a solid support to prevent the deformation of the crystallized mass upon the expulsion of the liquid portions, a piece of metal cloth is employed to hold the mass against a grating during the process of centrifugation.

The porosity of the plates thus obtained is so great that after they have been soaked in water, the latter can be entirely expelled by placing the mouth close to one side and blowing vigorously. In short, these plates are actual metal sponges.

EXHIBIT FROM PRIVATE MARKET GARDEN AT FAIRBANKS, SHOWING THAT ALASKA IS NOT ALL SNOW AND ICE

Uncle Sam's Last Free Lands

The Role of the Cow and the Plow in Interior Alaska

By J. Paul Heritage

FIFTY years ago men predicted that our free lands would last five hundred years. Such a comment did not consider our great railroad development and heavy immigration. Now if the soldier gets a farm he will usually receive cut-over lands, or swamp areas recently drained. Since the early nineties, the demand for free lands has threatened the supply. The corn belt farmer, when farm values climbed, went to free lands in Canada, our own semi-arid region in the West, or came back to the abandoned, almost free farms in the East and in New England. Unless we intensify greatly, drain or irrigate vast areas, we will soon need new lands.

Uncle Sam has a lot of free land for his sturdy sons who possess the same pioneer spirit which pushed across the Appalachians into the fertile prairies of the middle West, up into cold, glaciated Wisconsin and Minnesota, and now on into dry farming sections about the one hundredth meridian. It is to Alaska that the free land farmer must look.

Alaska is called our Arctic province, but is three-quarters in the Temperate Zone. Secretary Seward, who urged the purchase of this territory, was severely criticized and the area was dubbed Seward's "Icebergia" and "Refrigerator." In 1898 discoveries of gold in the Klondyke and at Nome made folks think Seward had been very wise, and Alaska was thought to be a mine of wealth. It is not, however, an iceberg, nor is it an Eldorado.

In latitude it is the exact counterpart of the Scandinavian Lands, which contain nearly 8,000,000 people, as compared to Alaska's less than 75,000. Pan-handle Alaska enjoys climate similar to the State of Washington, which is so highly praised by Dr. Ellsworth Huntington, in his "Civilization and Climate." This area has abundant rainfall (100 inches). Interior Alaska along the Yukon and its big branch, the Tanana, has less rainfall (25-30 inches), but generally sufficient for a cold climate, which has scanty evaporation. The winters are rigorous, but not much more severe than those of Dakota and Montana.

The common idea is that such northern climes are unproductive agriculturally. Interior Alaska, however, has one great advantage given her by nature. This is the long days of summer. The great amount of sunlight and the absence of many cloudy days are a God-send to northern areas like this, and make agriculture possible. Many places have luxuriant vegetation as the illustrations show. The vegetable seems at home in this clime. The white potato is the king of northern crops. It will grow in the southland but it seems to thrive in the climate of cool nights and not too hot days. It does not demand a long season. Turnips and cabbage are rivals for second honors. Peas, tomatoes, radishes, lettuce and cauliflower are among the familiar products. Foreign plants such as the rutabaga, a Swedish turnip, and Swiss chard, are good.

The Experiment Stations at Rampart and Fairbanks urged the growth of potatoes for some years. In 1911 they had made a little impression on those whom they were urging. In that year there were said to be 1000 tons of potatoes shipped into Fairbanks from the Puget Sound District. Since that time, however, there has been response to the suggestions until the district faces the bogey of all vegetable growers—over-production. Perhaps Alaska will solve this problem by using the potato to make alcohol for gas engines. There is no thought of doing this at present, however, and without adequate transportation facilities, Fairbanks must feed its surplus spuds to the pigs. In 1911 the tubers brought $12 per bushel. At recent prices, $1.67 per bushel, they are no bonanza. In fact, with teams at $12.50 per day, it probably does not pay. This applies only to the Fairbanks area, however, where the excellence of the conditions seemed to have spurred the development beyond normal.

Some 900 tons were raised in the Fairbanks district at last report, and one-third were raised within two miles of the station. The Experiment Station having convinced the farmers that potatoes could be grown, reduced its acreage and now disposes of the seed, or feeds them to the pigs. The Government authorities do not desire to compete with the growers. The Station will continue the growth of the potato, however, since it reiterates that it considers the cultivation of this plant the equivalent of a summer fallow, a practice which otherwise would be necessary.

The Stations have, on small plats, grown at the rate of 700 to 900 bushels to the acre. On five acres they averaged 200 to the acre. Larger areas averaged 150. One farmer, in 1914, reported 230 bushels as the average for a 7-acre field, and on a small place he got at the rate of 330. It is not to be expected that yields would always be nearly this high, but it is given to show that they can be grown and apparently about as well as anywhere in the country.

The argument for the potato is well summarized by one agricultural report, which says "The potato is by long odds the most important item in the people's diet. Everybody uses it, everybody knows how to grow it, and, with proper care, it can be grown all over the territory." This is rather flowery for an Experiment Station report, but it is the opinion based on considerable evidence. Rampart, where some of the records are taken, is 300 miles north of Petrograd, Stockholm, and

Christiana, and parallel with the central part of Iceland. Norway and Sweden grow potatoes as well as other crops in areas comparable to these.

It is a generally accepted principle that northern grown seed is hardy and quick maturing, and therefore desirable for use in southern climes. Hence Aroostock County, Maine's most northern section, is the greatest potato seed section in North America. Transportation of such bulky product would be a handicap in Alaska, in this respect, but what about turnip and cabbage seed? The turnip is a plant which the Northerners are willing to back against any grown in the South. These roots also have value as human food as well as food for hogs. The various root crops thrive well in this region and offer great possibilities for the future.

Some consider cabbage next to the potato. In 1911, Puget Sound cabbage was said to be found in every grocery store in the territory. Some progress has been made in eliminating this useless transportation. One farmer claims to have sold sixteen tons of cabbage from a half acre. At this rate, overproduction will become a factor in this product.

As to the success of vegetables, an actual grower says "Lettuce always does well. Cauliflower is the finest I have ever seen or tasted. Swiss chard was tried for the first time, and was very fine. It can be cut about every ten days." Another farmer says "I had a splendid crop last year. I had four acres under cultivation, and I raised about 300 sacks of turnips, about 100 sacks of rutabagas, 150 sacks of potatoes, and about 100 pounds of cabbage. I also raised eight Hubbard squash, weighing 16 pounds each, that were also ripe." A third man raised 1000 head of cabbage, much better than those he had raised in Washington, and raised 5 tons of potatoes which he characterizes as the finest he ever saw.

So far it seems that forage crops do not thrive as well as vegetables. They require a longer season, and if perennial, are likely to be all or partly winter killed. The Experiment Stations have been doing yeoman work on this problem. It is a painstaking task and requires years to demonstrate effectively. Alfalfa, the crop mainstay of many an area, is much desired for this region, and the work so far has been fairly encouraging. Rampart had announced it a sure success, but in the winter of 1914-15, it was winter killed. It is hit heavily when snow is off the ground in spring. The Siberian alfalfa bloomed, but did not seed, therefore could not perpetuate itself. Some fourteen varieties are being grown, with the desire to get one that is hardy, yet retains the yielding qualities. It is claimed that even if it has to be sown every spring, it is of probable value for hay that year, with its value as a legume thrown in. Nitrogen is an element sadly lacking in this soil, or if present, is unavailable.

The Experiment Stations object that they have not yet been able to give alfalfa a perfectly fair trial in this northern section. The plants had to be brought from Sitka, a journey of 2000 miles, which long journey caused them to arrive in a poor condition. Much work will be done with alfalfa, for the worth of this plant is so great that it will not be easily given up. If alfalfa should fail, as seems unlikely, vetch may be its substitute. Clover, a legume, is unable to survive the winter, according to several experiments.

Hay has been imported from the United States at great cost. This seems inexcusable. Native grasses abound in many areas and make excellent silage. Oat hay can be grown most anywhere, although timothy has been a disappointment. It has frequently been too thin to cut.

The grains are exceedingly important for man and animals and progress has been made in growing them on a fairly large scale. Barley is thought to be the best grain for the area. This grain, at home as well as in the Mediterranean climate, thrives even above the Arctic Circle. It is thought that it will answer the needs of man as well as those of animals, should the more popular wheat fail. Barley, while containing less gluten than wheat or rye, is nevertheless the grain food of quite a portion of the people of North Europe, as well as many desert peoples. It also serves as a substitute for corn as animal food. It is possible that the absence of gluten may be partly solved by plant breeding. Hybridization has already approached a successful beardless variety of barley which will make it much better as animal food. Some twenty varieties are being grown and the yield has been as high as forty bushels to the acre.

Oats and rye are also being grown. Finnish Black Oats in 1915 were reported as growing forty-two bushels to the acre. Two years previously, twenty-five acres were cut for hay. Nine varieties have been grown and all ripened. Oats are much used in Norway and Sweden and seem to thrive well in Alaska. Rye usually ripens without serious damage. It had been supposed to be an absolute success, but, like alfalfa, it was hard hit in 1914, when only half a crop survived.

Wheat has been the object of much attention. Winter wheat has not fared well. Kharkov wheat was imported from Russia, but this needs some two and a half feet of snow as a protecting cover. Alternate freezing and thawing in spring are generally disastrous to wheat. In one year but twenty-five per

A STAND OF RYE AT THE RAMPART EXPERIMENT STATION

OATS AND BARLEY (*LEFT*) AND RUSSIAN SPRING WHEAT (*RIGHT*) AS GROWN AT THE FAIRBANKS EXPERIMENT STATION

cent survived. It also gets too heavy rains in August. It was announced in a recent report (1913) "that no winter wheat hardy enough had been found."

Spring wheat is up against the possibility of frost in August or September which would prevent its ripening. Nevertheless, for most of the interior, spring wheat is doubtless better than winfer. It has survived some cool waves in August. The last report shows that a crop of forty bushels to the acre has been raised. Buckwheat has been considered a probable grain, although this has been frost nipped.

The situation may be said to be encouraging as far as grain, hay and legumes are concerned and further experimentation bids fair to make success more certain. These crops suggest animal industries since in most places these products are fed in large quantities to animals. Before entering a discussion of this problem, let us review the limiting factors affecting agriculture and therefore indirectly, animal industries. Among them might be mentioned the following:

1. *Climate.*—The severity of the climate calls the pioneer, the man whose wife and family are willing to bear conditions on the frontier. Here they may get a homestead tract if they are willing to endure the hardships incident to the pioneer life. The lack of rainfall may necessitate some irrigation in the interior, although the small evaporation is an offset to this. Particularly, there must be an intelligent selection of crops adapted to the temperature and soil conditions, following the lead of the experiment stations.

2. *Soil.*—Frozen for seven months it has no chance for chemical change. Thus a crop every other year is equivalent to one yearly in warmer climates as far as soil action is concerned. The ground needs fertilizer. If imported, this doubles the price on account of expensive transportation and makes its use, except in small quantities, prohibitive. Fish refuse and sea-weed may help solve the problem, and if animals are kept they will aid.

3. *Limited Market.*—Once the local market is supplied what then? Will the population increase? There will be much further mining, fishing and trapping, no doubt, and forests will be utilized. These industries will make additional markets. Transportation will probably for a long time prevent the shipping out of agricultural products of bulk, although the Government railroad from Fairbanks to the south coast should be a great aid.

4. *Labor.*—The farmer must bid against the mines for labor; and even under Alaskan prices, he can scarcely afford to do it. He finds it difficult to attract the laborer who has come for the conquest of gold and settle him down to the more prosaic occupation of farming. The native may finally be of some use in this respect as soon as he finds there are goods he desires beyond those of primitive times.

As to the inherent possibilities of animal industry, there are few cattle or hogs in central or northern Alaska. The Experiment Stations are continually asking for an appropriation to import Siberian yak. It is proposed to breed this animal with the Galloway cattle, a Scottish breed now being raised on Kodiak Island. This breed of cattle is small, and cannot get larger on native grasses. With grain, they should grow. The yak is a sure footed animal. He supplies raiment for the Siberians and even drags their plows. The cow gives milk capable of being made into butter—a merit which that of the otherwise virtuous reindeer does not possess. In Thibet the yak is used for transportation. Its flesh is good meat. The animal seeks its own food, does not fear the cold, in fact, is content to lie in the snow or swim in cold lakes.

TYPICAL ALASKAN-GROWN VEGETABLES: THE POTATOES FROM FAIRBANKS, THE CELERY FROM SITKA

A discussion of grains proves that the feeding of cattle can be solved. Farmers near Fairbanks are going into the industry. One has forty-five cattle, and he is eloquent in praises of the Yukon meadows. One of the interior stations reports wintering thirty cattle, feeding them on native grasses, red-top hay, yellow turnips and silage. Occasionally, steers are driven across the country to be fattened in this vicinity. Potatoes are excellent feed for these animals. Root crops are also advantageous. Two or three farmers were raising hogs near Fairbanks in 1914. Until feed is raised easily, they will scarcely pay at present prices. The animals must be protected from the cold by artificial heat. Full blooded animals are kept by the Experiment Station to sell to the farmers.

Sheep and goats would seem adapted to parts of Alaska. Sheep are raised somewhat at Kodiak Island to the south, but have not been attempted much in the northern sections where the rainfall is insufficient to give good pastures. Exportation of hides, a product of high value and small bulk, should be an important one for an area short on transportation facilities. The new Government road from Fairbanks to the south coast should be a great help in solving this problem.

A hotel 100 miles from Fairbanks had just burned down when the great traveler, Frank G. Carpenter, saw it. Reports to him said that this hostelry had kept 650 hens, 50 ducks, 70 pigs, 25 horses and 8 cows. Not many years before it was reported that some 60,000 cases of eggs were shipped from Seattle to Fairbanks alone, one-quarter of them being hauled over the ice at great expense. They were sold as high as two dollars per dozen, and the local ranch eggs were considerably higher. Bishop Rowe, who has traveled through much of this area, reports eggs as selling at a dollar apiece. The poultry industry would seem to have possibilities there.

Dairying is being tried on Kodiak Island and seems possible of extension. The Galloway cattle are supposed to be the best for such climes; Alaska in its southern part has great possibilities in this respect as Scotland, Norway and Sweden are prominent in them, and Danish butter is known all over the world. The interior has inferior pasturage, less rainfall and on account of the intense cold, would be a less attractive place for extensive animal raising. Two dairy herds were kept at Fairbanks in 1914. The winters are admittedly trying on the Galloways. It is for this reason that the yak is desired. Milk was sold by the farmers at 50 cents per quart.

The fur industry is an old one and while others have long since surpassed it, yet it is of importance, as over a million dollars' worth of furs are got yearly. In its influence on the people, it is small, and its future does not appear great. Instead of chasing the animals through the forests or setting traps in their haunts, the modern scheme is to raise them in your own back yard. There are ten or twelve fox farms in the territory. One at Copper Center is typical of what is done or what can be done in other places. At this farm there were in 1916 some two hundred foxes, three of which were sold for $10,000 apiece. The farm at Baker Hot Springs which is located on the Tanana River, near where it joins the Yukon, has paid as high as $15,000 apiece to the Indians for black fox pups. One farm has a capitalization of $300,000. Judge Moran has a farm on the Kobuk, and he says foxes are as easy to raise as cattle and hogs. He thinks the industry has brilliant prospects. Canadians are said to have sold silver foxes for as high as $25,000 a pair.

Many fur animals are diminishing, but the muskrat is a fellow who has held his own. He multiplies more rapidly than others. His fur is valuable and many claim he is excellent as meat. It may be that selective breeding will be introduced so that this industry will soon be removed from the trapping stage to the farm.

The reindeer industry is one of great moment to the natives, who use it for transportation, food and clothing. It saved their lives when their food supply was threatened. As a factor in our own meat supply, it has possibilities, and reindeer flesh is already being imported. The American cousin of the reindeer, the caribou, had never been domesticated, so the importation of the real reindeer had early been considered. In 1851

POTATO FIELD AT THE FAIRBANKS STATION (*LEFT*) AND PART OF A CABBAGE CROP AT SKAGWAY

Prof. S. F. Baird advocated the move. Nothing definite was accomplished until nearly 1890, when Dr. Sheldon Jackson, a minister, who was General Educational Agent in Alaska, became much enthused over the project. After many discouragements, finally, Congress was persuaded to act. Dr. Jackson was assailed by the newspapers which accused him of endeavoring to make way with the public funds, and one Grand Jury threatened to indict him. Having a large amount of stick-to-it-iveness, however, he won out, and in 1891, with the aid of his assistant, Mr. W. T. Loop, prepared to bring in the animals. Sixteen were landed the following year. The work has proceeded under the auspices of the Department and the Missions to a most successful outcome.

Dr. Jackson saw that with the disappearance of the whaling industry, the introduction of fire arms, with their destructive effect on game, and the reduction of good fishing, the natives were headed for starvation. He reasoned, with abundant good sense, that it would cost the Government many millions to feed these people but it would cost only a few thousand to teach them to support themselves. This he knew was the only method which would instill self-respect and insure against pauperism.

The experiment was a risk. None in Alaska knew much about the details of management. Siberians and Laplanders had to be imported as instructors and there were various problems incident to the introduction of both man and animal. Chief among the expected difficulties was bothering by dogs.

These animals infest Alaskan ports but their annoyance to the deer proved largely fictional, certainly nothing to be compared with the damage the canine does to sheep in this country. Wolves caused some stampeding, there was trouble at the birth of the animals, some died on the journey before food could be obtained, an interpreter was hard to secure, and the Siberians did not take kindly to the enterprise, fearing they would lose the trading of their deer skins for the oils which they desired from the Alaskans. All of these difficulties were solved, although they were of no small amount.

In 1917 there were at least 100,000 deer in the territory. The increase is largely the natural one since importation was stopped in ten years by the Russian Government, after only 1200 had been secured. In a recent year, 13,000 were killed locally for meat and skins. It has been estimated that at the present rate of increase the number in 1925 should be 800,000 and 1930 should be 3,000,000. These estimates are based on the fact that the number doubles every two or three years. New stations are being added from time to time, and the entire Arctic Tundra, as well as a large share of the Yukon basin, contains the valuable moss on which the deer makes its meals.

The animal is docile and affectionate. He does not try to use his horns on the attendants. Full grown at three years, he is then between four and five feet in height, and seven feet in length—from nose to tail. The usual weight is 250 pounds. The horns measure two and one-half feet from tip to tip. He is broken in harness at two years of age and this procedure, as with horses, is not entirely without excitement.

The reindeer has proven a god-send to the natives. Instead of their scanty provisions they can now have delicious steak, and if they follow the example of the Lapps they will eat every scrap of meat available. The doe gives milk suitable for drinking, if diluted, and capable of being made into cheese, but not butter. That the Eskimo has not availed himself of the milk to a marked degree does not detract from the probable use for the future. The animal furnishes shoes, boots and clothing—reindeer coats having been imported by the natives before the industry developed locally. The sinews are spun into thread and the antlers are made into various household ornaments and utensils. Whatever is left is manufactured into glue or boiled into soap for dogs. This equals the story of the pig which is all utilized except the squeal.

The service of the deer as a transporter is in some ways the most notable. Getting the food from moss relieves him of the necessity of carrying his provender. The dog, on long journeys, cannot carry enough food for his own needs. One man can manage a team of reindeer, whereas it is customary for a dog team, composed of several animals, to have two masters. The deer will outdistance the dogs, traveling 100 miles or more a day, if necessary, although it is inadvisable to attempt more than thirty on a long journey. He will go eighteen to twenty miles an hour for short distances, but should not be driven in excess of twelve for long periods. One pair is said to have hauled 1600 pounds. Here again, of course, the amount for a long journey would have to be a small fraction of such a record. The reindeer have been used to carry the mails, to carry soldiers, and have gone on rescuing expeditions of several hundred miles, as the one to Point Barrow years ago, when the natives were at the point of starvation.

Deserving natives are given deer after serving an apprenticeship with the Siberian or Lapp trainers. At the end of one year a native is given two animals, the second year five and at the end of the fourth, thirty-six. The girl who gets a "reindeer husband" is the envy of her friends. The Lapps say three hundred deer will support a family. Many in Alaska have that number; some Lapps in the homeland have five thousand to ten thousand. It has been wisely provided that the natives cannot sell their female deer, thereby keeping the white man from absorbing the industry. Lapp trainers receive the deer as part pay for their services and they may sell. In this way white men have acquired some. One company on the Seward Peninsula is said to own twelve thousand. The Missions were given deer to be returned at the end of six years, the Missions to keep the increase.

Commercializing this industry has been difficult for the white man. This is in part due to a fundamental difference in purpose. The white man in business wants the Eskimo to develop the reindeer, whereas the Department of Education introduced the reindeer to develop the Eskimo. Another observation is that the native is disinclined to work for the white man, but does well for himself. Unless the family aids, the job of tending the flock is generally one of twenty-four hours daily, requiring duty in blinding blizzards and Arctic temperatures. This does not appeal to the white man with his eight-hour day in a heated factory.

As our country becomes more populous it is natural that we will follow the Orient and Europe and reduce our meat consumption. This rule would be violated only if we could secure a supply from outside sources at a low price. Will the reindeer ever become a factor in our meat supply? In the present, no, but in ten to twenty-five years the answer seems much more likely to be in the affirmative. There is now, according to estimates, an area six to eight times that of New York State, unsuitable for agriculture but with rich pasture for deer. This area should support 10,000,000 reindeer. When it is considered that cattle of all kinds in this country in 1914 numbered about 55,000,000, the potentialities of the new industry are apparent. The possibility of such a number in two decades presumes no ruthless destruction. So far, only the excess males are killed.

Lapland sends 22,000 to market annually. Norway and Sweden exported the meat and smoked tongues to Panama during the construction of the canal there. The first shipment from Alaska left for Seattle in 1911. One hundred and twenty-five carcasses, totaling nine tons, were sold, some cuts as cheap as twenty cents a pound. Shipment was not permitted until there was a sufficient supply for the natives in the home districts. One writer saw a thousand deer ready for the butcher in 1916, and fifteen hundred was the amount set for 1917. This author, who has had world-wide observation, thinks venison will become as common as beef and mutton, and will be shipped to every town in the country. Recently it has been claimed by others that extensive exportation of the deer is mythical.

There is little doubt that it can be sent to our Pacific ports. The populous market, however, is in the East. This would involve an additional 3000 mile rail journey, unless the route by Panama were used. As to whether this market is to be reached, possibly we have a fairly analogous case in the beef raised on our western plains which is shipped to Chicago in great quantities to be slaughtered there for world shipment. It may happen that the price of beef will be prevented from its upward soar through fear of this competition. Canada could aid much in raising these animals. Dr. Grenfell purchased a few for Labrador some years ago, but they have been lost sight of in the other famous enterprises with which his name has been associated.

One of the limiting factors for further growth is said to be the amount of moss available. After the 10,000,000 limit is reached, there is still the possibility of feeding the animals. Experiments have shown that it can be done, but if it becomes necessary to buy feed, the great favorable point, free provender, will be gone. Forest fires are also said to threaten the life of the moss. Another limiting factor is the ignorance of the natives. They are more scared of a new idea than our most reactionary politicians. It is said that our cattlemen and breeders could secure more rapid increase of the animals if they would direct the enterprise. Introduction of caribou blood is thought to be a probability for the near future. The quantity of milk given, now about a tea-cup full, could probably be increased. Witness the breeding that makes a cow commonly give twenty or thirty quarts daily whereas in olden times she barely gave enough to support her own calf. Hoof

rot and hoof diseases are troubles which in time may require considerable expert advice.

For the pioneer, Alaska offers more abundant opportunity. The future of this area lies not with the miner, but with the farmer and the herdsman. Gold and coal and copper will be exhausted, but agriculture, if scientific, will go on forever. The experience of China, where farms have been successfully tilled for forty centuries, is illustrative of the fact that this industry is the enduring one. Alaska calls for settlers while her lands are free.

GRAPE SEED OILS

By E. KLINGER

VERY little is found in the technical literature concerning the oil that is extracted from the seeds of grapes. Only a few facts regarding the analytical constants of the oil are given in the standard reference books (*cf.* Lewkowitsch).

Grape seed oil has a specific gravity of 0.9202 to 0.9561, a saponification number of 178 to 179 and an iodine number of 94 to 96.2 according to Lewkowitsch. Because of its partial solubility in alcohol it is classed together with castor oil and because of its low iodine number, it is considered as a non-drying oil. However, information from various localities in Spain, where the oil is used largely, served to indicate that it was mixed with linseed oil or else used alone in making paints. This appeared to be in direct contradiction of the data published on this oil, and because of the importance of this product as a possible substitute for the more expensive linseed oil, a thorough large scale investigation of the properties of the oil and its applications was undertaken.

GENERAL PHYSICAL AND CHEMICAL PROPERTIES

The oil was light yellow in color, clear and had a pleasant vinous odor. The specific gravity was found to be 0.95, the saponification number 191 and the iodine number 130.5. The fatty acid was isolated from the oil and its saponification number was found to be 199.5, iodine number 133.5, melting point 23 to 25 deg. Cent. and solidification point 18 to 20 deg. Cent. All these analytical results were checked several times. The high iodine number indicates at once that the oil is a drying oil or at least a semi-drying oil. In this respect it is much like poppy seed oil or sunflower seed oil. Tests were undertaken to determine just how good a drying oil it was.

It was found that crude grape seed oil dried in four days but gave a very sticky film. Even after the coating of oil had remained exposed for a long time, it did not lose its stickiness. The absorption of oxygen by the oil was 7 per cent in four days in comparison with 14.7 per cent in the case of linseed oil during the same period of time. A grape seed oil varnish, made with 5 per cent lead manganese resinate at 180 deg. Cent. dried quite rapidly, but gave a very sticky film just as in the first case.

Other grape seed oil varnishes, prepared with different lead, manganese and cobalt salts, gave similar results. The cobalt salts had the property of causing the oil to dry more quickly than any of the other salts. In every case the coating of varnish was sticky after it had dried.

APPLICATIONS

Further tests indicated, however, that when the oil was used in conjunction with a certain proportion of cling wood oil very good results were obtained. The oil is recommended for use in this manner as it gives just as good results as straight linseed oil and is much cheaper, which makes the paint or varnish cheaper as well. The mixture of wood oil and grape seed oil contained 2 parts of the former and 1 part of the latter. It was heated to 180 deg. Cent. and mixed with 4 per cent of lead manganese resinate. The varnish gave a faultless coat with a lacquer-like finish and was not sticky after it had dried out. The oil may be used with linseed oil in the proportion of one to two, one to one or two to one in making varnishes for use in painting where it is not important that the varnished surface remains sticky. The china wood oil and grape seed oil varnish is very efficient for varnishing floors and for other decorative purposes.

It was also found that when the grape seed oil was heated for a long time it polymerized slightly. Heated at 290 to 300 deg. Cent. for 1½ hours it became very viscous and after two hours it could be drawn out into strings. Shortly afterward the contents of the vessel solidified into a rubber-like mass, which exhibited linoxyd properties after cooling. In comparison with linseed oil, the polymerization took place much more quickly. This would suggest a possible use for the oil in the manufacture of oilcloth, etc.—E. Klinger, *Farben Zeitung*, 26, 6.

GENELITE

A NEW material known as genelite has been developed to serve as a self-lubricating bearing metal. It is a high grade synthetic bronze, containing 40 per cent graphite by volume in the July number of *Mining and Metallurgy* and the SCIENTIFIC AMERICAN for June 11 the following particulars are given:

Tests have shown a high degree of porosity, the metal being able to absorb as much as 2½ per cent by weight of oil. This characteristic is made use of in high-speed applications, where oil is applied to the outside of the bushing and carried through to the bearing surface by capillary attraction. Another characteristic is that the bearing never seizes or freezes, or, the metals of the shaft and the bearing never flow or weld together. If a bearing sticks, owing to too close a fit, all that is necessary is to reassemble it with the proper fit, no damage being done to the shaft or bearing.

Among the self-lubricating uses for the new bearing are brakerod bushings, clutch centering bushings, throttle control, fan- and pump-shaft bushings, where such material saves much trouble and expense of overhauling and repair. On the main engine, genelite has proved useful for places such as main bearings, crankpin bearings and piston-pin bushings which are supposed to be well lubricated at all times, but where wear is likely to be excessive due to the oil losing its lubricating value from dilution by unconsumed fuel, or insufficient oil.

Genelite is made from the oxides of tin, lead, and copper, composing a high-grade bronze, plus graphite, all the materials being in a finely divided state. Graphite is added in sufficient excess quantity to reduce the oxides to the metals and leave the required graphite content in the finished material. The oxides are partly reduced by heating the mixture. The mixture, still in powdered form, is then pressed as nearly as possible to the required shape in massive metal molds. In this pressed form it will not stand much rough handling, so it is given a final bake, which sinters the metals together into a homogeneous bronze, holding the graphite uniformly distributed throughout its mass. The baking serves to clamp the graphite particles securely within the mass of bronze, so that they cannot be washed out or detached save by dissolving away the surrounding metal with acids.

The material has the general appearance and body of bronze, but the characteristics are different. It does not machine readily by the ordinary methods, but can easily be ground, which has been found to be the best method of handling it in quantity. Neither has it the physical characteristics of bronze, having very low tensile strength, but withstanding high compressive strains.

When considering the relative performance of bearings, all the factors entering should be given due consideration. A self-lubricating bearing should never be compared with a lubricated one, for no bearing will give as good results unlubricated as a similar bearing properly lubricated. But it is sometimes necessary, due to inaccessibility of parts, or neglect on the part of the user, to install bearings that are self-lubricated. In such places genelite is in a class by itself.

The Oldest Plants in the World*

The Psilophytes: A Newly Discovered Class of Fossil Plants of Remotely Ancient Origin

A GREAT many persons have demanded of me an answer to the very naïve question: *Where does such and such an animal or such and such a plant come from?* The problem of the origin of things has profoundly impressed their minds—for this problem is buried in shadow and in mystery. However, it is not worth while to try to solve it by means of more or less fantastic hypotheses. . . . It is certainly better to say frankly that one is unable to answer a question than to simulate even a rudimentary amount of knowledge. For this reason it becomes us to exhibit extreme prudence with respect to the origin of the plants which adorn our globe. In spite of the really immense progress made during the last half century in the science of Paleobotany, *i.e.*, the science of fossil plants, or rather of those petrified remains of them which have been preserved in various strata of the earth's crust, we are still far from being able to give a complete and definite answer to the question regarding the form in which the vegetable kingdom had its birth.

What were the first plants in existence? The answer is lost in the abyss of time, and it would appear that there is no fossil which has been capable of preserving these original habitants of the earth.

The oldest *known* terrestrial plants belong to the Devonian period; all of the previous geological epochs, *i.e.*, the Silurian, the Cambrian and the pre-Cambrian appear to be lacking entirely in fossil plants. Beginning with the Devonian, on the contrary, the continental floras underwent a prodigious development down to the Carboniferous age, the exuberance of whose vegetation is borne witness to in the deposits of soft coal and anthracite in various parts of the earth's crust, since these deposits, as a matter of fact, consist of plant débris. Without entering here into details as to the form of the Carboniferous age, we may state its principal elements as follows:

1. The ferns.

2. Horse-tails, similar to the horse-tail which grows in our own times in marshy meadows and woods; these plants possess non-branching stems bearing at regular distances rings or whorls of small leaves.

3. Lycopods; these are plants of a kind at present confined to mountainous regions, but especially abundant like mosses with us, in tropical forests. The stalks and roots of the lycopod are branched in successive forks and their branches are covered with scales.

It is necessary to add that the ferns, the horse-tails and the lycopods of the Carboniferous age, instead of being comparatively small, as at the present time, were all *arborescent* or tree-like in nature, attaining a height of from 30 to 40 meters.

When we pass from the Carboniferous to the Upper Devonian, we find that the flora, though more restricted in character, being less rich both in individuals and in species, is still capable of being described in terms such as apply to the plants of our own time. It contains in particular the gigantic arborescent fern, known as the *Archacopteris Hibernica* found in the southeast part of Ireland, the large lycopod *Bothrodendron* of the same region and the wide-leaved *Pseudo-bornia* of Iceland. All of these plants are leaf-bearing and are related in their general characteristics to the ferns, the horse-tails, the lycopods, *i.e.*, to the vascular Cryptogams.

But this ceases to be true with respect to the extremely archaic plants found in the Lower Devonian. An immense gap separates these from the former. Here we open our book of Paleobotany at a special chapter devoted to a new class of vascular plants, called the Psilophytales, a name recently invented to classify the most ancient terrestrial plants thus far discovered.

Previous to the year 1913, only the single genus *Psilophyton* was known to belong to the flora of the Lower Devonian age. This genus had been discovered by the English geologist, Dawson, in certain fossil specimens which were too poor in their contents to create a general conviction of the correctness of his view. Later discoveries, to be sure, made near Lake Röragen, on the line between Sweden and Norway, enabled Dr. Holle to affirm the existence of spiny, cylindrical stems, having neither leaves nor roots, but provided at times with terminal sporanges and corresponding closely enough to the *Psilophyton princeps*,

The rock-borne records of archaic flora are by no means so complete as those of the primeval fauna of the world, which is natural enough considering the fragility of the originals. Consequently, botanists all over the world are rejoicing in the comparatively recent discovery of some admirably preserved petrified plants belonging to an extremely remote geological era, probably the Lower, certainly not later than the Middle, Devonian. While this important discovery was made in 1913, it is only very lately that the silicified plants have been described by the paleo-botanists in charge of the work, Dr. Kidston and Professor Lang, whose studies in fact are still unfinished. The deposits were found in a bed of chert in Aberdeenshire, Scotland, by Dr. Mackie of Elgin. The plants formed beds of peat mingled with layers of sand, an arrangement which indicates a succession of turfy layers of soil, covered with colonies of plants, and subject to inundation from time to time. The whole series was finally covered with water containing silica.

These ancient peat bogs have already thrown much light on various vexed problems and fruitful discoveries are still expected by those in the progress of the work. The accompanying article from the pen of the French scientist, Leon Bertin, furnishes an excellent idea of the three genera of plants already described, the Rhynia named from the locality, Rhynie; Hornea from Dr. Horn, a former director of the Geological Survey of Scotland, and the Asteroxylon.

A specially interesting point is the comparison suggested between these plants and certain red algæ. This fact is regarded by some authorities as lending some color to a theory recently propounded by Dr. Church of Oxford, who expresses the view that at the very dawn of geological history, the earth was entirely covered with water, and that from this (ionized salt) water life was evoked by the energy of the sun. This first phase of plant life was, of course, plankton, but as portions of the earth's crust were forced upward from internal strains, certain areas of the bed of the sea came near enough to the surface to make it necessary for these small organisms to adapt themselves to the new conditions. From the encysted flagellates floating in the water, there developed, according to Dr. Church, plants anchored to one spot. He is of the opinion, furthermore, that this condition lasted for millions of years, during which time these anchored plants became highly complex in structure—far more so, indeed, than any seaweeds of the present time. Finally, a third phase was entered when the land emerged from the sea, so that the ocean dwellers were obliged perforce to become land dwellers or else perish. If this view is correct then, to use Dr. Church's expression, "The beginnings of botany are in the sea." The picture drawn by Dr. Church is very different from that imagined by some geologists who take us back to an era when the rocky crust was bare of all vegetation. The bearing of this upon the present paper is obvious.—THE EDITOR.

*Translated for the *Scientific American Monthly* from *La Nature* (Paris) for Jan. 1, 1921.

as the prototype species, described by Dawson, is called.

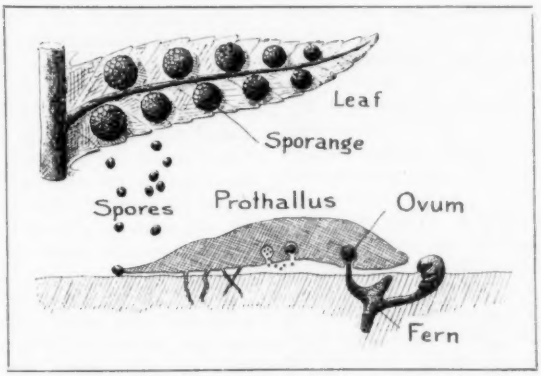
DISCOVERIES OF FOSSIL PLANTS IN 1913

A memorable date in Paleobotany is the year 1913, for in that year a discovery was made of a bed of fossil plants in the Lower Devonian (the epoch of the Old Red Granite) contained in a bed of turf from 2 to 3 meters in thickness, near the village of Rhynie in Aberdeen County in Scotland. Four silicified vascular plants capable of being studied under the microscope in the most minute detail have been obtained from this now celebrated deposit. These plants have been made the subject of an extensive study by Kidston and Lang (Transactions of the Royal Society of Edinburgh, Vols. XLI and XLII).

All four belong to the group of the Psilophytales, but differ so greatly from each other and from *Psilophyton* as to be classified in 3 genera, which have been called *Hornea*, *Rhynia* (containing 2 species), and *Asteroxylon*. The first two have both leaves and roots. The latter has no roots and but rudimentary leaves.

I. *Hornea.*—This is a sort of rhizome. It possesses rhizoids upon its lower surface, and from these there rise several bifurcated stems about 2 mm. in diameter; these stems are traversed throughout their entire length by a central cylinder surrounded by woody fiber. The central cylinder exhibits the same dichotomic ramifications as the stem which encloses it. At the end of the branches and forming simple differentiations of the latter are sporanges which are apparently indehiscent. The spores are tetrahedric in form.

II. *Rhynia.*—This plant, *Rhynia major*, is larger and better preserved than *Hornea*, but it has an equally simple structure. From the rhizome there arise several stout cylindrical stems, in which the microscope reveals a central cylinder having a bark and an epidermis provided with stomata. The latter and the vascular tissue furnish a proof that this plant was aerial in habit. The branches end in sporanges 12 mm. in length, having no columella or central axis and filled with tetrahedric spores.



THE ALTERNATION OF GENERATIONS IN A VASCULAR CRYPTOGAM

Rhynia Gwynne Vaughani, the second species of the genus, is smaller than *R. major*. Moreover its stems spring from toward the base of a sort of peduncular buds, *i.e.*, stem-buds, of superficial origin (possibly from the epidermis), and serve the purpose of vegetative multiplication, like the organs of the same kind found in some of the higher plants.

III. *Asteroxylon.*—Its base is formed by a rhizome branched in the same manner as that of the Stigmaria (the rhizomes of the *Lepidodendrons* and the *Sigillaria* of the Carboniferous Era), but naturally much smaller, since all of the plants of the Lower Devonian, including *Asteroxylon* were low-growing plants. In *A. Mackier* the stems were only 1 cm. in diameter. As in *Hornea* and *Rhynia* they were branched in successive forks, sustained by libero-ligneous bundles and ending in sporanges. It is necessary to dwell a bit upon these peculiarities in the anatomy of the plants.

In the case of a thin slice cut from the silicified stem of an *Asteroxylon*, just beneath one of its bifurcations, the central cylinder shows wood starred like that of certain lycopods. On the outside we see the sections of several leaves and the bundles which run to them.

The epidermis is pierced by stomata, which serve for the passage of the gases respired and for the assimilation of chlorophyll. In a longitudinal section it can be seen that the vessels are not sclariform, differing thus from those of the vascular Cryptogams. Finally, the microscope reveals the existence in the cortical cells of the stems and rhizomes of mycorhizes or filaments of symbiotic fungi, just as we now find them in the roots of forest trees of today.

The sporanges of *Asteroxylon* are comparatively small and are pear-shaped in form. Their dehiscense appears to have been terminal, whereas the sporanges of *Hornea* and *Rhynia* were indehiscent. From several points of view therefore *Asteroxylon* was more highly organized than the other two fossil genera of the *Rhynia* lignites.

A comparison of the foregoing plants with the *Psilophyton* of Dawson shows that there existed in Europe during the Lower Devonian epoch a remarkably homogeneous flora, composed of rootless land plants. They are archaic in nature, not only because of the lack of roots, but also because of the location and the structure of their sporanges.

The modern plants which most closely resemble the Psilophytals of the Devonian are the two genera *Psilotum* and *Tmesipteris*. The most common of the former, *P. triquetrum*, grows in the warm and humid portions of the tropics. It is a small plant which has no roots. Its rhizome is covered with rhizoids, and abundantly supplied with mycorhizes, whose office it is to assist the nourishment of the plant, which would otherwise suffer because of its very small leaves. The latter, indeed, are merely rudimentary, or rather they are reduced to the axillary bracts of which the sporanges consist. The whole, bracts and sporanges, send up from the surface a large number of tigellae or radicals borne by the rhizome; these are profusely branched in dichotomy.

Tmesipteris is represented by a single species (*T. tannensis*) found in Australia and New Zealand. It usually grows on the trunks of tree-ferns. Its form recalls that of a *Psilotum*, except that the rhizomes are more elongated and the leaves less rudimentary.

Holloway has shown that the embryo of *Tmesipteris* lacks roots from the very beginning of its formation. This indicates apparently that the absence of roots is primitive and not the result of a secondary reduction.

Before attacking the difficult problem of their alternation of generations it is advisable to sum up all the characters common to the *Psilophyta*, both of modern growth and of fossil origin. The six genera forming the group of the Psilophytal plants are as follows: *Psilophyton*, *Hornea*, *Rhynia*, and *Asteroxylon* in the Lower Devonian, together with *Psilotum* and *Tmesipteris* of our own day. All of these plants are vascular and do not bear flowers or seeds. But they are distinguished from the true vascular Cryptogams (which include ferns, lycopods, and horse-tails) by the lack of roots. This negative character causes them to resemble the mosses. But in their external aspect and some details of their anatomy (the wood starred in cross section) they approximate the lycopods.

In these plants therefore we possess *mixed or synthetic* types, which lessen the distance long thought to exist between the mosses and the vascular Cryptogams.

"It may be," says Professor Bower of the University of Glasgow, "that these two great phylums of terrestrial plants have diverged from a common stock. But this stock must have been closer to the plants of the Lower Devonian than to any other known plant."

We have spoken of the stems and leaves of the Psilophytals. But do these terms really fit the case? Do they represent organs really homologous to the true stems and leaves of the higher plants?

This question has been debated by learned botanists. Bower is of the opinion that the leaves of ferns, for example, which bear sporanges, have their origin in the enlargement and flattening of the stems of the Psilophytals. The sporanges, which are at first terminal, in the less highly organized ferns (*Osmunda, Ophioglossum*), just as they are in the Psilophytal group, come to occupy a central position on the lower surface of the leaves in the higher types of ferns; this, of course, is a mere change of position which is of secondary importance. But if the stems of the Psilophytals correspond to the leaves of the vascular Cryptogams and Phanerogams then what value should be attributed to the leaves of a *Rhynia* or a *Tmesipteris?* And what value again to the stem of a fern? Bower has suggested that the stems and leaves of the higher plants underwent a simultaneous differentiation, starting with the stems of the Psilophytals, and that the leaves of the latter are foliary excrescences without any homologue in other plants. However this may be, the important thing to remember is that the terrestrial plants of the Lower Devonian were remarkably simple in structure, having neither roots nor true leaves—somewhat resembling a green thallus.

Everyone knows that a fern—and the same thing is true of all the vascular Cryptogams—reproduces itself by means of the spores which are formed in the sporanges and fall from these, when ripe, to the ground. Let us follow the development of one of these spores (figure). It swells and expands and gradually produces partitions until finally a prothallus is formed, but this prothallus is by no means a new fern plant, since it has neither leaf, stem, nor root. In spite of this lack it lives upon the ground, obtaining nutriment from rhizoids, from chlorophyll and from microscopic fungi.

This prothallus is termed the *first generation*, and this generation even possesses the property of sex, since it is capable of forming ovules. From these ovules there spring a *second generation*, namely, the adult fern which is without sex, but produces *spores*.

But these ovules develop in the interior of the prothallus so that the ultimate plant is nourished by the prothallus during its youth, not becoming free from the first generation until later.

Now let us suppose that a fern does not become detached from its prothallus, but continues to obtain nutriment from the latter, while the roots, becoming useless, because the rhizoids of the prothallus take their place, cease to appear. In such a case the combined prothallus and leaf-bearing plant would form a nondescript rootless organism. But it is just such an organism which the *Hornea*, *Rhynia*, and the *Asteroxylon* of the Devonian most resemble. That part of the *Hornea*, indeed, which we have termed the rhizome has all the appearance of a prothallus persisting at the base of leaf-bearing stems.

The prothallus of the *Psilotum* and of the *Tmesipteris* was discovered in 1914, shortly before the outbreak of the Great War. The careful descriptions which have been made of it reveal that it was composed of colorless membranes living in symbiosis together with mycorhizes upon decomposing vegetable matter. This lowly form of life is amazingly similar to the prothallus of the lycopods.

INDUSTRIAL PRODUCTS FROM FISH AND MARINE ANIMALS

WE have read many times that it is possible to make a very good leather from fish skins, but there are other products of commercial importance which are derived from fish and other sea animals.

The most important of these are the oils that are obtained from these animals and which have many important industrial uses. These oils are mainly codfish oil, whale oil, herring oil, menhaden oil and spermaceti. The last named product is really not an oil in the strict sense of the word, but a liquid wax. It does not contain glycerine and is constituted of fatty acids combined with the higher alcohols instead of the usual glycerine.

Fish oils are found on the market in various grades. The grade of the oil is determined by the method used in its production, by the nature of the raw material from which it is made and by the process of refination. A good example of how the grade of the oil determines its usefulness is found in codfish oil or cod-liver oil, as it is generally called. The best quality of the oil is used in medicine, while the lower grades are used in the manufacture of leather.

The extraction of the oil from the liver of the fish and from the fish itself at one and the same time is a technical detail of the greatest importance. To obtain the best quality of cod-liver oil, the fresh, clean livers are heated in caldrons which are provided with steam jackets. The oil exudes from the liver and floats on the surface of the mixture. From injured, diseased or putrid livers an oil of industrial use only may be obtained. In this case it is unnecessary to take as much care in the extraction process as in making the medical oil. During the last few years many extraction plants have been installed on the fishing vessels themselves, which has tended to reduce the chance of putrefaction of the raw livers. On the other hand there are processes where the livers and the flesh of the fish are extracted separately.

An oil is made from a mixture of all sorts of livers, good and bad, which is employed for various industrial purposes. It is used particularly in the manufacture of chamois leather. In the tanning of such leather, this oil is caused to penetrate into the sheepskin by suitable means and the skins are tanned due to the oxidation of the oil. The excess oil is recovered by pressing it out of the tanned chamois or by washing the latter with hot water. This expressed oil is known as degras and is very much sought for by leather makers and curriers. The demand for this product is so great that certain plants manufacture the product allowing the cod-liver oil to oxidize in the presence of sheep-skin waste. The oxidized oil is drawn off and new oil is added to the tanks in which the process takes place, the same sheepskin waste serving for repeated oxidations.

The deodorization of fish oils is an important process and there are many ways of accomplishing this. Without a doubt the best method is to hydrogenate the oil, that is to treat it with hydrogen gas. However, when this is done, the oil is hardened at the same time and a solid or semi-solid fat is obtained according to the degree of the hydrogenation. By the use of this method it is possible to obtain a fine white fat from an oil with very pronounced color to start with.

There are other methods of deodorization, but these are not as effective by any means. Fullers' earth may be used, and more recently pine wood sawdust has been reputed to give good results. Whale oil and other fish oils are used to considerable extent in the manufacture of soluble or sulphonated oils. Spermaceti oil is used for lighting purposes.

The composition of a great many fish oils has been determined by a Japanese chemist, who found that they all contain a very large proportion of unsaponifiable matter. This is due to their high content of a new hydrocarbon, called spinacene. This fact makes the oils entirely unsuited for soap making. It may be possible to convert these oils into fatty matters which can then be used in the manufacture of soap, in the same way that the Germans converted unsaponifiable mineral hydrocarbons into fatty acids and even into the neutral fats themselves.

Another product that has been made from fish is fertilizer and cattle food. The same product may be used for the two purposes with but a slight variation in the process of manufacture. In the case of the fertilizer the oily content of the meal is of no value to the farmer and in fact he prefers that it be absent. So, when the fish meal is intended for fertilizer use, the oils contained therein are removed with solvents. On the other hand, when it is to be used for cattle food, the oils are of considerable advantage and consequently are left in.

The Art of Writing and Its Early History

The Evidence of Ideography in Our Written Language Throughout the Ages

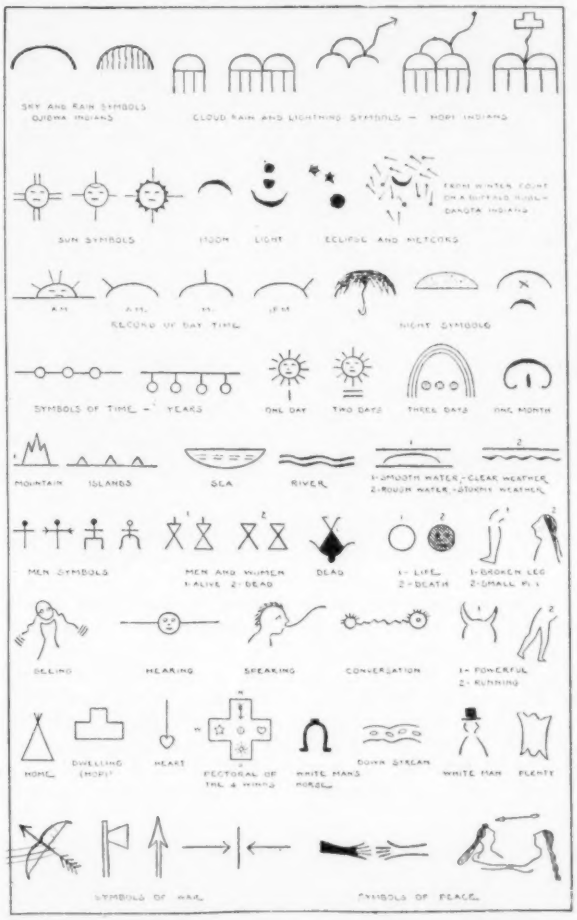
By Albert A. Hopkins

Fellow American Geographical Society

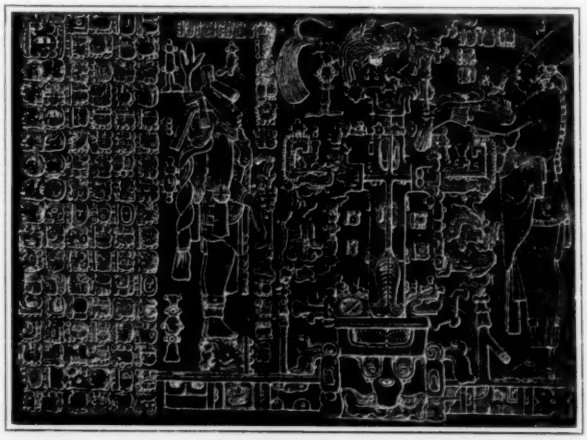
EVERYONE who reads a printed page in any modern language must have wondered at some time or other how writing as a permanent record of his own thoughts ever came to be used and also used as the representations or symbols of spoken words. Our processes of thought in the ever-widening environment of these busy modern days have become so automatic that we are prone to lose sight of the historical evidences of the long constructive past written large over the pages of our voluminous present. There is a whole volume of human history back of every one of the twenty-six alphabetic characters with which we write our thoughts and it was with this idea in view that Mr. William A. Mason has recently written an excellent book entitled "A History of the Art of Writing" which has just been published by The Macmillan Co. The bibliography of works on the art of writing is a long one, and occupies seven pages of Mr. Mason's work and could be extended to even far greater lengths by patient study. The two books which loom up from the sea of material are the book mentioned and Dr. Henry Smith Williams' monumental work entitled "Manuscripts, Inscriptions and Muniments," which was issued a few years ago in elephant folio form and which has recently been published at Cambridge, England, with a curtailed number of plates. It is to Dr. Smith's courtesy that we owe nine of the interesting illustrations which accompany this article.

The record unfolds to us the life history of these characters which have been designed, shaped and molded by many successive artists toiling under palm and pine; each are in turn modifying, altering and simplifying them, using them for the day and generation of his own race to pass them on as a priceless inheritance to other nations. If we examine the pages of a printed book in a European or Asiatic language (Chinese or its derived scripts being omitted) we will discover that the intended thought of the writer is conveyed to the mind of the reader by means of printed characters of abstract form which represent spoken words and which "spell out" the words phonetically, syllable for syllable, as they are pronounced. This basic principle holds true even though the English language may shake the fabric somewhat. The printed words that we read which are made up of the present, purely arbitrary characters which we know as alphabetic signs, convey to the mind through these abstract symbols word-pictures comparable to the primitive ideographic-idea pictures, which were the ancient precursors and prototypes of these symbols. These printed or written words of the classical parchments, the mediæval manuscripts and the modern books, it must be remembered, stand for the phonetic names of the intended things, representing them to the mind. By long association, however, these word-symbols, despite their apparently arbitrary character, call up to the mind of the reader the corporate things themselves; not only their names, but their forms, qualities, or attributes that the thousands of words in the language have come to represent. They are all idea-pictures as well as sound-pictures. In fact, they were idea-pictures first, ages before primitive culture of advancing man arrived at the conception of using these pictures as signs to represent phonetic sounds.

It is the purpose of Mr. Mason's book to prove by incontestible evidence that practically all systems of writing can be traced back through successive stages of development to a primitive age, long



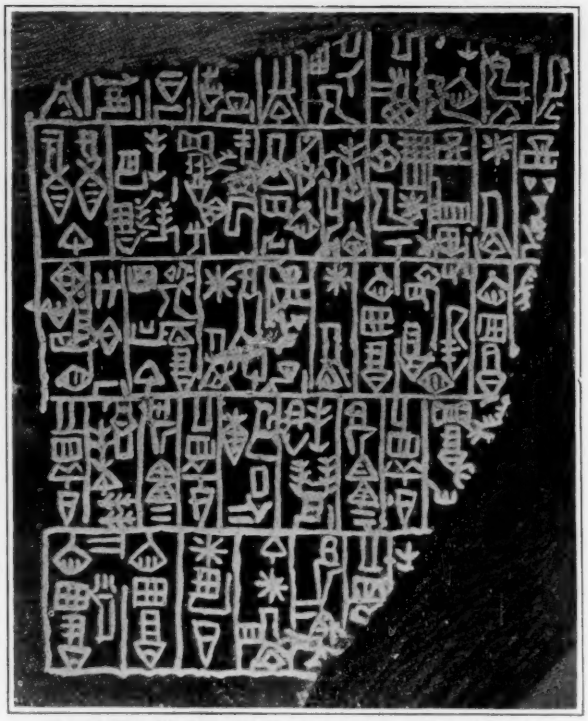
GRAPHIC SYMBOLS SELECTED FROM PICTOGRAPHIC RECORDS OF AMERICAN INDIANS (AFTER MASON)



MAYA HIEROGLYPHS, PROBABLY EARLIER THAN 1500 A. D. (AFTER WILLIAMS)

anterior to the invention of letters, when all records were merely the pictures of the things or ideas expressed. We have only to look about us in the world to discover that we have had quite up to the present generation, in the records of the aborigines of our own land, in the writing of the Chinese and of other nations, the contemporaneous use by different peoples the world over, of almost every phase of this world-wide and age-long evolution of the wonderful art of writing. For national development in the matter of writing has been most unequal. Some nations for one cause or another — racial backwardness, isolation, servitude or other unhappy causes contributing to it—never to this day have evolved any system of written record; while other nations, some even contiguous through all the centuries to these laggards in civilization, invented and practised the art of writing and enjoyed its beneficent results many millenniums ago. The African tribes, as is well known, though in contact with Egyptian civilization and its high culture over three thousand years before Christ, have failed up to the present day to develop any indigenous system of writing; while the history of Babylonian writing runs back to the fifth pre-Christian millennium. It is probable that the Homeric epics were chanted from memory during the early years of the second millennium before Christ, ere contact with the Phœnicians conferred upon the Greeks the art of perpetuating their heroics in visible, graphic form. The Romans, just before the birth of Christ, finding the Gothic barbarians of northern and western Europe illiterate and possessed of no other means of record than tallies of knotted cord and notched wood, taught them to write with the Roman letters. And the descendants of these same Europeans in the 16th and 17th centuries, coming in contact with the aborigines of this Western Continent, discovered them like children studying the primer of writing and drawing the pictures of the things and ideas that they desired to remember or to impart to others.

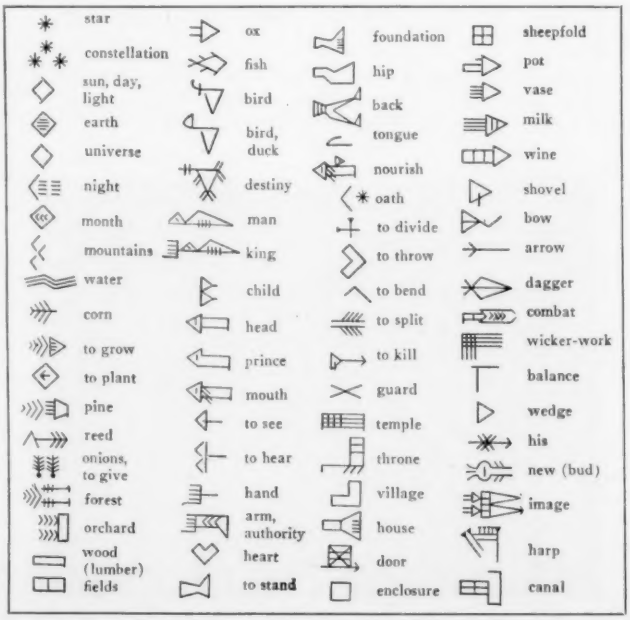
It doubtless will be a still greater surprise to the reader to be told that there are yet retained in our language not a few of the primitive pictures that antedate writing, altered and modified, to be sure, through ages of use, during which interval they have become greatly simplified and conventionalized. All written languages contain these silent witnesses of their pictorial origin, existing like the persistence of ancestral traits in individual tribes; or to be nearer our point, like the roots of their spoken words converging different dialects back to a common linguistic parent.



OLD BABYLONIAN WRITING (AFTER WILLIAMS), ON BLACK BASALT FROM ABOUT 4500 B. C. ANTEDATING THE CUNEIFORM, NO GENERAL AGREEMENT HAS BEEN REACHED AS TO THE TRANSLATION

The reader will notice in the pages of the book we are considering besides the alphabetic characters which we hope to be able to show later on probably are the corrupted forms of primitive pictures, other characters used as the representation of words that are not phonetic at all, but at a casual glance seem as arbitrary as the letters themselves, the component parts of printed words. They are in reality conventionalized pictures, in many cases retaining an indubitable resemblance to the things which they represent.

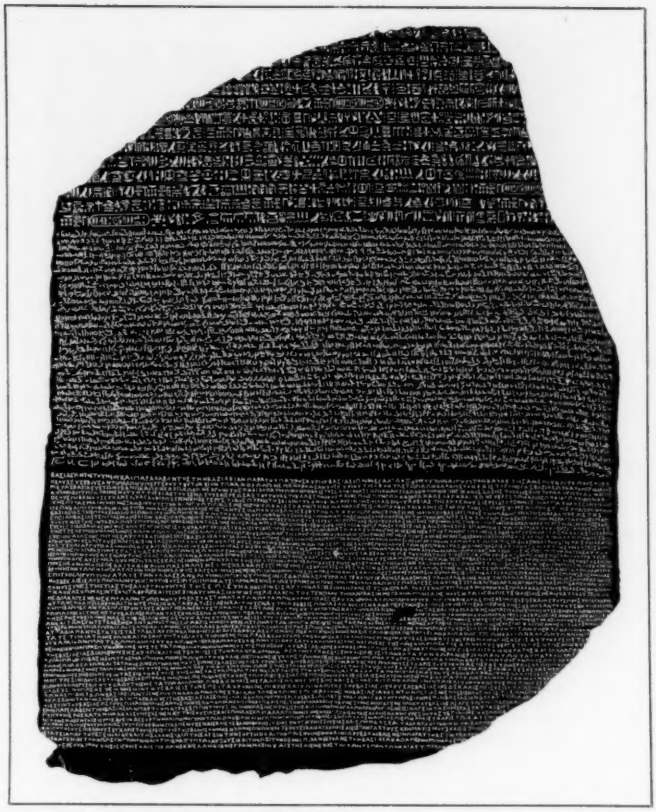
It will require no special appeal to the reader's imagination to foreshadow to him that this story of the evolution of writing deals with one of the most momentous agencies in the intellectual advancement of man. No other influences that man ever exerted has reacted so powerfully upon the development of his mental and spiritual nature as the invention of writing. Without the art of writing man would still be a savage as benighted as the unlettered heathen who still inhabit Darkest Africa. Without writing to conserve current ideas and ideals and transmit them to posterity, all advance in intellectual attainments, all uplift in spiritual thought that was not transmitted through the uncertain and errant instrumentality of memory would be lost. The acquisition of the art of writing above everything else distinguishes the civilized nations from the barbaric tribes; and whenever paleographic evidences are first met with in the life-history of any nation, we may confidently assert that the people practicing the art of writing, however crude the signs employed, were well advanced in the scale of civilization. It is this fact that makes any inquiry into the origin of writing a peculiarly interesting study, and the person who approaches the subject sympathetically will be amply rewarded, for he will see at every stage the noble strug-



BABYLONIAN IDEOGRAPHIC SYMBOLS (AFTER MASON)

gle, pathetic at times, of man's emergence from his primitive barbarism and awakening to a conscious sense of his obligations to others, and of his ultimate high destiny.

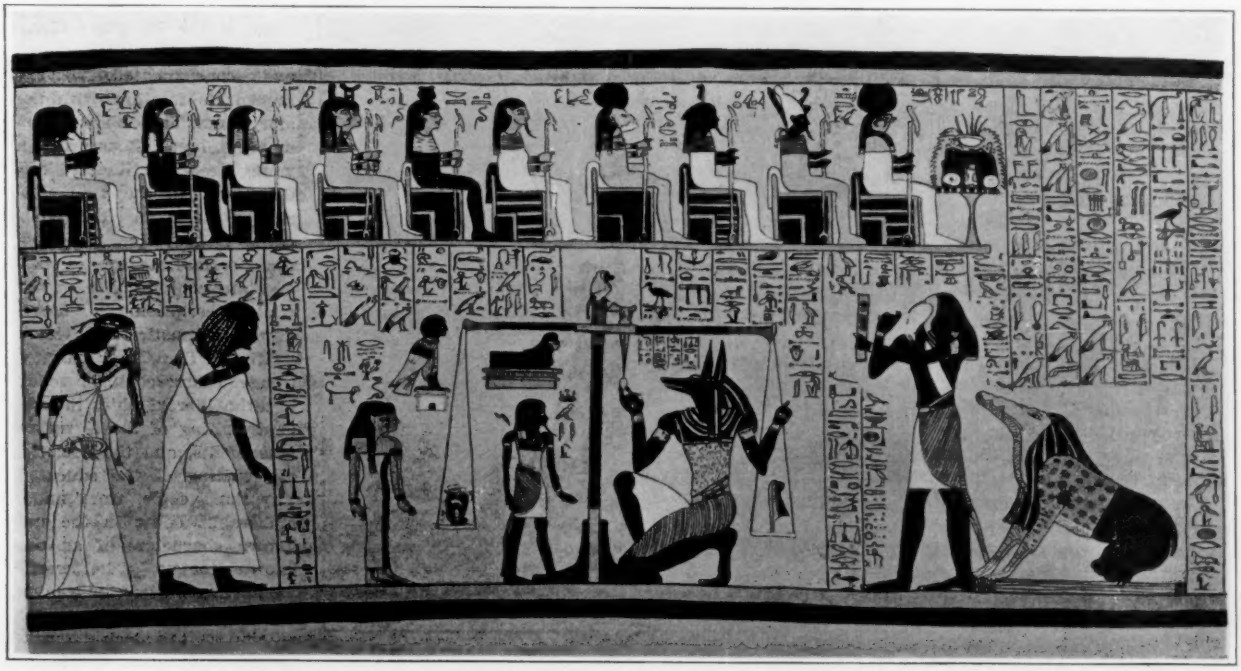
Mr. Mason's second chapter deals with primitive picture writing and gives as evidence interesting examples of rude pictures carved on bone by prehistoric artists, the rock paintings of the bushmen, such methods of computation as the clog almanacs, etc. The picture writing of the North American Indians comes in for an entire chapter in which the author shows that at the time of the European settlement of this country that the natives already had a system of picture-writing, wide-spread in its use but of limited comprehensibility even among the members of the same tribe or family. No tribe had advanced further toward true writing than the most elementary stage, that of pictography—drawing the picture of the thing intended, to recall it to the mind of the reader. The Dakotas and the Ojibwa Indians were about entering upon the second stage, that of ideographic writing when the intrusion of European culture interrupted the natural development of their native graphic system. We give an illustration from Mr. Mason's book showing the graphic symbols selected from the pictographic records of the North American Indians.



THE TRILINGUAL INSCRIPTION OF THE ROSETTA STONE IN THE BRITISH MUSEUM

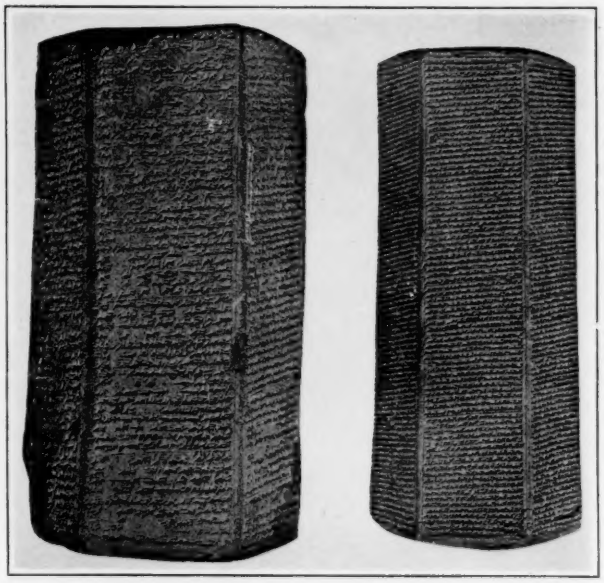
The fourth chapter is devoted to the picture writing of the ancient Mexicans and Mr. Mason says: "At the time of the Spanish conquest in the 16th century there existed contemporaneously in Mexico two centers of civilization, the Maya in the peninsula of Yucatan and the Aztec in the broad table-land of central Mexico where the present City of Mexico stands. Judged by the very scant remains of the arts of architecture, sculpture and writing saved from the ruins of these two Indian nations, their civilization and culture were quite the same, though the Maya was somewhat farther advanced than the Aztec. But the conquest of the country was so complete and thoroughgoing that when these Europeans had finished with their preliminaries, there was hardly a vestige of native culture left for rehabilitation.

"Cortes had no regard for any form of religion that was not based on orthodox Christianity. He was a religious bigot, so common in that age. Witnessing, therefore, religious ceremonies cruel in themselves and repugnant to his inherited beliefs, he ordered the destruction of every record that might



THE EGYPTIAN BOOK OF THE DEAD, IN THE ORDINARY HIEROGLYPHICS (AFTER WILLIAMS)

perpetuate this native religion. Obeying his harsh orders to the letter, his equally ruthless and ignorant followers set out upon the systematic destruction of the thousands of books, manuscripts and documents which this really highly advanced civilization had accumulated up to that time. Zumarraga, first bishop of Mexico, burned the precious manuscripts by the 'mountain heap,' five cities alone yielding up 16,000 books to the relentless Spanish governor, who destroyed every leaf. In Yucatan a similar fate overwhelmed the Maya civilization. The Spanish priests destroyed all books and manuscripts wherever they were found. Diego de Landa, second bishop of Yucatan, wrote: 'We find great numbers of these books, but as they contain nothing that did not savor of superstition and of the devil, we burnt them all; at which the natives grieved most keenly and were greatly pained.' Out of the tens of thousands of these sacred ceremonial books used by the Maya priests in their temples, and possibly other forms of native literature of a secular character, only a paltry few fragments are known to have been saved from this heartless and bigoted destruction.



BAKED CLAY CYLINDERS OF THE ASSYRIAN CUNEIFORM
Left: The annals of Essarhaddon, 681-668 B. C. *Right*: Annals of Assurbanipal, 668-626 B. C.; both from British Museum

"But the Mexicans progressed a long step beyond the ideographic stage of writing. While they had not reached at the time of the conquest the point where each sound was indicated by a sign or a hieroglyph, they had arrived at a transition stage between the purely ideographic and the phonetic stage of writing. According to Dr. Daniel G. Brinton, the well-known Americanist: 'the native genius had not arrived at a complete analysis of the phonetic elements of language, but it was distinctly progressing in that direction.'

"In the Maya inscriptions, written or sculptured, it is evident that there were employed together with the ideographic pictures other elements, known as glyphs or calculi from their resemblance to pebbles, which symbolized syllabic sounds."

In the next chapter Mr. Mason discusses the hieroglyphic writing of the South Sea Islanders which is most interesting and then Chinese ideograph writing is taken up but space forbids to mention even more than the chapter heads, for we must pass to the hieroglyphic writing of the ancient Egyptians.

"Of all the systems of hieroglyphic writing that the people of any age have devised for recording or transmitting thought that of the ancient Egyptians stands preeminent, and looms in the popular imagination as the hieroglyphic system par excellence. It is the one that has given its own and the classic name to all such systems of writing. It maintains this unique position not alone on account of its historic and romantic associations, but for the artistic perfection, variety and clever ingenuity of its wonderfully fascinating symbols. Nothing in the way of writing ever has equaled the Egyptian hieroglyphic writing for its quaint picturesqueness, its extreme human interest, or for its beautifully decorative effect, whether sculptured on stone, painted on tombs or written on papyri. Entirely apart from their literary content, the arrangement of the hieroglyphic characters on the temple facades, friezes, columns, and over the broad wall spaces, added ornamental effectiveness to the architectural construction and enlivened its severe monumental dignity with their picturesqueness and variety of detail.

"In Rome there had stood since the time of the Cæsars as many as twelve Egyptian obelisks brought from Egypt by the early emperors to adorn the temples of the Eternal City. The import of their hieroglyphic inscriptions was not even guessed for over eighteen hundred years. It was not until Napoleon's spectacular invasion of Egypt offered the opportunity, that the decipherment of the Egyptian hieroglyphs was finally attempted and consummated. Every student is familiar with the story, now an historic romance, how Boussard, a young French artillery officer, discovered in the year 1799 near Rosetta, a few miles from Alexandria, the now famous Rosetta Stone, a slab of slate containing a tri-lingual inscription in hieroglyphic, demotic and Greek writing. The Greek inscription of course could be read; but the hieroglyphic, the sacred writing of the Egyptian monuments, and the demotic, the writing of the educated Egyptian people, were undecipherable, being in the unknown characters of an unknown tongue. The world long had awaited the genius of French initiative and scholarship to unlock the mysteries of Egyptian epigraphy and was immediately to be

CUNEIFORM WRITING IN THE PERSIAN (ARTAXERXES III), RECORDING THE KING'S TITLES AND GENEALOGY AND THE COMPLETION OF HIS PALACE

enlightened. Jean François Champollion, a noted French scholar, turned his attention to the inscriptions and applied his scholarship to their translation with the most memorable success. He detected and rightly guessed that the name of Ptolemy, plainly read in the Greek inscription, was contained within the cartouches or ovals, several times repeated throughout the hieroglyphic inscription. It is now known that the royal names always were so written within these cartouches. Champollion previously had seen on the island of Philæ, before the Temple of Isis, an obelisk, since removed to Corfe Castle, England, with a single vertical line of hieroglyphics down the middle of each face consisting mainly of cartouches similar to those in the Rosetta inscription. Fortunately, at the base of this obelisk were two inscriptions in Greek, a petition to Ptolemy Energetes II., consort of Queen Cleopatra, by the priests of the Temple of Isis, and the reply of the king.

"Little did these very clever priests of Isis dream that this stele, erected through such a transparent but successful palaver to the august Ptolemy, ultimately would become a potent factor in the decipherment of the hieroglyphs in which the inscription was written; far transcending in importance the trivial cause of its dedication and erection. Champollion in his investigations noted the similarity of the cartouches of Ptolemy in the Rosetta stone and on the obelisk of Philæ and subsequently identified the cartouches of Cleopatra in the latter inscription. By the help of common letters in the two names he was soon able to assign phonetic values to the twelve different hieroglyphic characters in these three cartouches."

The subject of cuneiform is very fascinating and Mr. Mason says:

"The full story of the origin of the cuneiform writing only lately has been fully demonstrated through the excavations conducted by the University of Pennsylvania at Nippur, by De Sarzec at Telloh, and other excavations in ancient Mesopotamia. In the higher strata of the débris of the ruined cities of Mesopotamia, containing the remains of the civilization of the middle and later kingdoms of Babylonia and Assyria, are found tablets containing inscriptions in the later cuneiform already referred to; but as lower and lower strata are reached, carrying us down to the remains of earlier cities, we find the characters gradually changing their forms from age to age, looking more like representations of actual things; until finally we come upon inscriptions in which the wedges have altogether disappeared, and each sign is drawn in lines—no longer writing as we know it, but veritable outline drawing. Thus may each puzzling cluster of wedges, which for a score of centuries served a great nation for the characters of its written language, a language exceptionally expressive and complete in its inflections, be traced back to its pictorial prototype. This early pictorial script, now known as the linear Babylonian, is distinctly representative, as we would naturally expect the archaic writing of a primitive people to be. In this respect it affords a confirmation of the theory of the almost universal pictorial origin of written speech. When all the missing links in the chain of development are supplied, it probably may appear that this early pictorial script was the parent from which have descended through the Hittite and Phœnician some of the letters of the Greco-Latin alphabet. It is yet too early to speak dogmatically in the matter, as so many transitional factors in the development are missing; but the weight of evidence seems to favor the far East as the source of some of our alphabetic characters."

DEVELOPMENT OF THE ROMAN ALPHABET FROM THE PHOENICIAN AND GREEK (AFTER MASON)

We derive much information from this book as showing the steps by which a written language has sprung from and developed out of primitive picture-writing as shown in one of our engravings. The hieroglyphic system of writing of the ancient Hittites claims a chapter, as does the alphabetic writing of the Phœnicians. We now come to the Greek alphabet and the subject is admirably handled by Mr. Mason in the limits of a single chapter after having worked up to this step by his evolution of the Phœnician alphabet as a probable source of the Greek alphabet. Mr. Mason says:

"No tradition seems ever more thoroughly substantiated, both by internal evidence and external fact, than that recorded by the Greek authors that the alphabet used in Hellas came from the Phœnicians. The classic authors differed in their opinions as to the origin of the Phœnician letters. Herodotus, the Greek, and Pliny, the Roman, believed that the Phœnicians invented the letters; while Brosius attributed them to the Babylonians and Tacitus to the Egyptians. But practically all the world now believes that it was the Phœnicians who introduced the letters into Greece proper."

We now come to Chapter XIII. which deals with the Roman alphabet. "The Roman alphabet, from which the capital letters of our English alphabet have descended with hardly the change of a single stroke for an interval of over 2000 years, was, according to the best historical evidence, developed from one of the early Greek alphabets, the Chalcidian, a variant of the Eubœan mode of writing. It was introduced into Italy at a very early date contemporaneous with the widespread Hellenic emigrations over the entire north Mediterranean shores, from the Aegean Islands to Spain, by Grecian colonists from Chalcis, who established themselves in Cumea, Sicily. It would appear that some time in the 10th century B.C., probably in the latter part and not so long after they had transmitted their precious alphabet to the inhabitants of

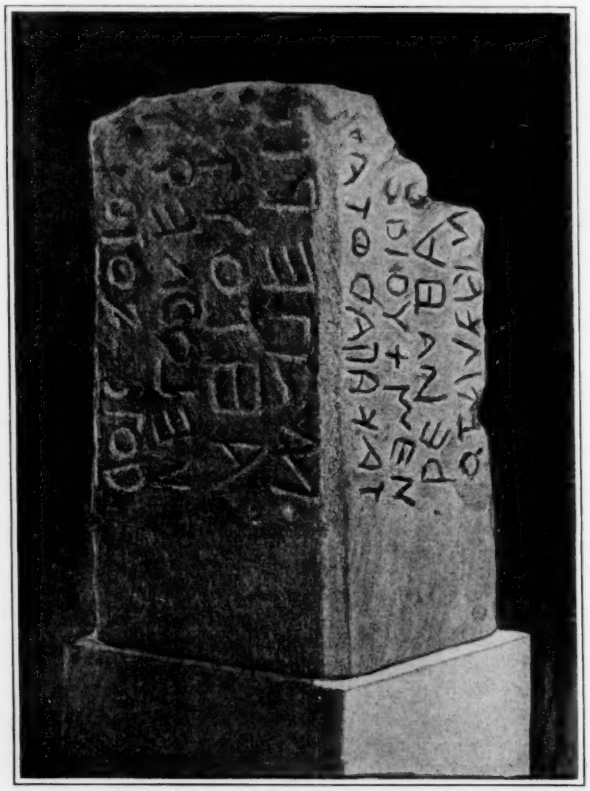
GREEK INSCRIPTION OF THE THIRD CENTURY B. C. (AFTER WILLIAMS). IT RELATES TO LAND OWNERSHIP

UMBRIAN BRONZE TABLET, PROBABLY EARLIER THAN 500 B. C. (AFTER WILLIAMS). IT REFERS TO THE SACRIFICE OF A SHEEP

Hellas, the Phœnicians retired from Greece and the Aegean. There then followed a rivalry for colonial supremacy among the Greeks. Miletus in Ionia contended with Chalcis in Eubœa, in Greece proper, for primacy in colonization. They eventually divided the territory of the Mediterranean between them, the Miletians being supreme in the east and through the Euxine, while the Chalcidians dominated Thrace and Italy. Thus it came about that the Western variant of the Greek alphabet was introduced into Italy," and after showing the evolution of the alphabet in a table which we reproduce, Mr. Mason goes on to say that:

"We now have reached in the classic days of the Roman civilization—a time about contemporaneous with the close of the Pagan period and the dawning of the Christian era—the complete development of the Roman alphabet. Its foundations were laid in the earliest Greek alphabets borrowed from the Phœnicians; its structure was framed by the Chalcidian, Pelasgian and Etruscan colonists in Italy; but the monumental perfection of these wonderful letters that the ages were so long preparing for us was the work of the Romans. The Roman letters in their extreme simplicity and remarkable mutual differentiation contain within themselves the elements of their popularity and widespread adoption. It is the most widely diffused alphabet in the world, being exclusively used in England, America, Australasia and South Africa, and is practically in use throughout Europe, except where the Gothic blackletter is employed in Germany and the Slavonic alphabet in Russia. It is also in official use in Egypt and India, and wherever the European nations except Germany, hold sway. The Arabic alphabet alone competes with it in universality, being used throughout Central Asia."

This does not terminate Mr. Mason's book for he deals (though briefly) with writing in the middle ages and the age of printing, but this occupies less than 100 pages. There is an excellent bibliography and the whole book bears the earmarks of the scholar who is enamored with his subject. It is a substantial contribution to serious literature.



ARCHAIC LATIN INSCRIPTION OF UNKNOWN DATE FROM THE ROMAN FORUM (AFTER WILLIAMS)

SELECTED BIBLIOGRAPHIES

SOME time ago attention was called to a report of the committee of the American Chemical Society giving lists of books in various special fields of chemistry which were recommended for public libraries in particular. The American Ceramic Society's Committee on Coöperation now reports a selected bibliography of books in the English language dealing with ceramic chemistry and ceramic industries which is a supplement to the section on industrial inorganic chemistry in the chemical reading courses. The list is given in detail in the *Journal of Industrial and Engineering Chemistry* for May, 1921. The principal headings are chemistry and the ceramic industry, clay and clay products, glass and glass manufacture, vitreous enamel, refractories and cements, limes and plasters.

Although the ceramic industries are among the very oldest, comparatively little has been done as yet toward placing the industry upon a real scientific basis notwithstanding the advanced work done by several laboratories and many individuals connected with the production of clay products. Wider reading of the books listed ought to be, therefore, of great value. There is an increasing tendency toward research in clay and clay products and there might be mentioned the present cooperative research work involving the Bureau of Mines, Bureau of Standards, and the associations composed of the manufacturers of heavy clay products. Before long it is hoped that this work can be extended to include white ware and finer clay products, giving them a substantially complete list of titles for the entire ceramic field.

The Chemistry of Human Activity

Interpretation of the Transformation of Energy That Accompanies Muscular Work

By R. Vladesco

THE principle of the conservation of energy established by R. Meyer can be verified in all the physical phenomena thus far known to us. The remarkable fact observed in the study of the radiactive bodies offers no contradiction to the principle of conservation, if we look upon matter as being merely condensed energy. Without this hypothesis the two principles upon which all the physical sciences are based, *i.e.*, the conservation of energy and the conservation of matter, would lose their value.

As for the vital phenomena it is possible to affirm from the knowledge thus far acquired that the principle of the conservation of energy is as applicable to them as to physical phenomena. The vital phenomena consist of transformations of energy and the quantity of energy brought into action is always equivalent to the quantity eliminated. In both the animal and the vegetable kingdom we are familiar with the initial and the final forms of energy. In the vegetable kingdom the energy penetrates in the form of light and of heat and we find it fixed in great part, in the form of chemical energy. In the animal kingdom the initial form is chemical energy and the essential final forms are heat and mechanical labor.

In order to attain the final form the energy introduced is first transformed into other forms concerning which we have no precise data, just as we have no precise knowledge of the intermediate terms of the metabolism of metal. It is quite possible that these intermediate forms of energy are among those with which we are familiar in the physical world; but it is not impossible, on the other hand, that they may be of a different nature. These forms, from the moment they are derived from known forms until that when they are transformed into known forms, could not possibly occasion us more surprise than did the discovery of electric energy. It is in this light that we should regard the physiological labor introduced into the science of Bioenergetics by Chauveau and the intellectual energy which is considered by Ostwald as being derived from chemical energy during the transformation of the latter into heat.

So far as muscular activity is concerned an endeavor has been made to define the nature of the intermediate forms which occur between the initial chemical form contained in the food utilized by the muscle and the work performed by the latter.

Numerous researches made along this line, especially by Chauveau, have shown that the muscles utilize the energy contained in glucose and that the chemical energy of this substance is exactly equal to that liberated by the muscle in the form of heat and of mechanical labor. The production of work is always accompanied by the liberation of heat and under the best conditions of labor not more than one-fifth of the energy utilized is transformed into mechanical labor, the rest being liberated in the form of heat. Since the transformation of caloric energy into mechanical energy is among the first and the best known of the transformations which take place, it was natural to suppose that even in the case of muscular activity the chemical energy is first transformed into heat and that this heat is then transformed into mechanical labor. But such a transformation is impossible by reason of the fact that if we assume that it takes place, even under those conditions in which the animal machine may be supposed to act like an ideal thermic machine, we find between the extreme limits of temperature compatible with life a yield of work done which is perceptibly smaller than that which results from experiment. As a matter of fact upon replacing T_1 and T_2 in the formula which gives the value of the work done by a thermic machine, which acts according to the cycle of Carnot, by 273 + 45 (45° exaggerated) and by 273 + 37 we obtain the value $\frac{T_1 - T_2}{T_1} = \frac{318 - 310}{318} = \frac{1}{40}$; a fact that is as yet comparatively little known. We find in fact the following statement in a brochure by A. Stein: *Die Lehre von der Energie* (collection: *Aus Natur und Geisteswelt*):

"Every production of work by our body corresponds to an equivalent amount of heat liberated from the latter. Every work done of 427 m. kg. causes the disappearance in our body of 1 kilogram-calorie. If the expired carbon-dioxide be collected we can determine therefrom the amount of the carbon which had undergone combustion and also the relation between the amount of fuel and the mechanical labor performed just as we can in the case of a steam engine. Energy constantly flows into the body in the form of food and oxygen, from which it obtains a portion of the energy through the heat of combustion which it transforms into mechanical labor. Thus we see that our body and together with it the whole world of organisms comes under the law which governs energy."

In the *Traité de Physique* of Albert Turpain we find the same concept (Page 478): "When the animal moves or performs any labor a part of the heat produced by the chemical reaction is employed to perform this labor. Measurements have been made which show that the quantity of animal heat produced per gram of oxygen absorbed is less during movement than during repose (Hirn's experiments).

The difference represents the mechanical energy expended. These experiments confirm the common observation that the temperature of the body is increased by muscular labor such as running or violent exercise.

It has been observed, indeed, that during motion the activity of the respiration is increased. The amount of oxygen absorbed and measured is accordingly much increased and suffices to raise the temperature of the body, even though a part of the chemical energy is employed in the external labor.

Neither can the series of transformations assumed by D'Arsonval: Chemical energy → electric energy → mechanical energy, be accepted as correct, since serious flaws may be found in it. Chauveau assumes that chemical energy, liberated by the combustion of glucose, creates and maintains in the muscle an elastic force which may be expressed by this formula:

$$F = \left[p \pm \frac{m\,v}{\theta}\right]\left[1 + \frac{1}{2\,k}\right]$$

And that this elastic force is totally transformed into heat in the case of static work, and into heat and mechanical energy in the case of dynamic work. According to the results obtained by studying muscular elasticity this hypothesis would seem to be fully confirmed. But the question at once arises: By what mechanism is the chemical energy transformed into this new form of energy, elastic force?

The facts established by Chauveau concerning the physiology of muscle enable us to interpret the transformations of energy which occur therein in a manner which does not contradict the facts proved by experiment and which is in accord with what we know in regard to extra vital energy. Chauveau has proved that the muscle in a state of activity receives more glucose and more oxygen than when at rest and that it sets free a larger amount of CO_2. He believes that the chemical process which takes place in the muscle is an oxidation process:

$$C_6 H_{12} O_6 + 6\,O_2 = 6\,CO_2 + 6\,H_2 O$$

But this very process involves a liberation of work done; it is the work which corresponds to the decrease of concentration of the glucose in the medium in which it is dissolved. Better

*Translated for the *Scientific American Monthly* from the *Revue Generale de Science* (Paris) for June 15, 1920.

to understand this let us imagine a hollow cylinder with semi-permeable elastic walls, filled with a solution of glucose in which oxygen is also dissolved, and in which, thanks to the presence of an oxydose a part of the glucose is burned in accord with the above equation.

By means of this chemical transformation the molecular concentration of the liquid inside the cylinder is diminished, and the decrease is proportional to the quantity of glucose burned. The carbon dioxide set free exerts no influence at all upon this variation of concentration, since for every molecule of CO_2 liberated a molecule of oxygen is consumed.

If the cylinder is immersed in water or in a solution having a lesser molecular concentration than that of the liquid it contains the water will penetrate the interior of the cylinder and its form will be modified (because of its elastic walls) having a tendency to assume the form of the maximum volume, *i.e.*, the form of a sphere.

This theory agrees with the known facts observed in histology, concerning the active and the resting muscle. Apropos of this I will cite the lines which follow from MM. Athanasiu and Dragoiu:[1]

"The active elements of the striated contractile substance are dark disks. . . .

"During the contraction these disks decrease in height and increase in thickness; the rods which form a part of these disks have a tendency toward a spherical form.

"The sum total of all these elementary modifications of the dark disks is revealed by the entire shortening of the muscular fiber and its transverse swelling. But we have seen that the clear disks are also deformed during the contraction: they are stretched in the transverse direction, as indicated by the flattening of their elastic grains.

Are we not justified in assuming that these simultaneous changes in form indicate likewise a material exchange between these two kinds of disks? It seems to me that it is quite natural to suppose that it is at the expense of the water in the clear disks that the dark disks increase in volume, as a result of the osmotic pressure occasioned by the combustion of the glucose.

But it is now necessary to find out whether the work produced by this chemical process is able to compensate the value of any sort of labor and to endeavor at the same time to explain the rather extensive variability in the yield of the work done by the animal machine.

Pfeffer's researches have shown that non-electrolyte crystalloid bodies in solution behave precisely like gases—*i.e.*, the formula of perfect gases can be applied to them:

$$P\ V = R\ T$$

No matter how complicated be the chemical reaction which takes place in the organism the work performed by it can be calculated by means of the equation of Van t'Hoff. In practice, however, we find that blind application of this equation leads to absurd results, even to infinite yield of work under some circumstances. It is necessary to modify the procedure by superposing upon the equation the physical limitations of the problem, so that the yield of work will be limited by the total amount of energy present in the substances under consideration.

If the reaction took place in the organism as has been supposed, and if the ratio between the concentration at the beginning and the end of the reaction were in excess of a definitely determinable value, then the animal machine would be unique and would represent the most perfect attainable device for the transformation of one kind of energy into another. However, in reality, of the total amount of energy contained in the chemical sub-stratum placed at the disposal of the muscle, only a fraction whose magnitude depends upon various conditions is transformed into mechanical labor, while most of the rest is changed into heat.

[1] I. Athanasiu and I. Dragoiu: *Association of the Conjunctive Elastic and Contractile Elements in the Smooth and Distriated Muscles of Mammals.* (In French Ann. de Biol. 1911, Vol. 1, No. 2.)

We could then determine the ratio of the concentration of the glucose existing between the venous blood and the arterial blood in the case of a muscle whose yield is known and reciprocally we could calculate the yield provided we knew the ratio between the concentrations, it being supposed, of course, that the muscle consumed no part of its glycogen reserves. The work done by this chemical reaction would be compensated consequently within the limits of the known energy of the glucose, for any sort of muscular labor no matter what and the variability of the ratio of the concentration—before and after the reaction—would furnish an explanation of the variation in the yield.

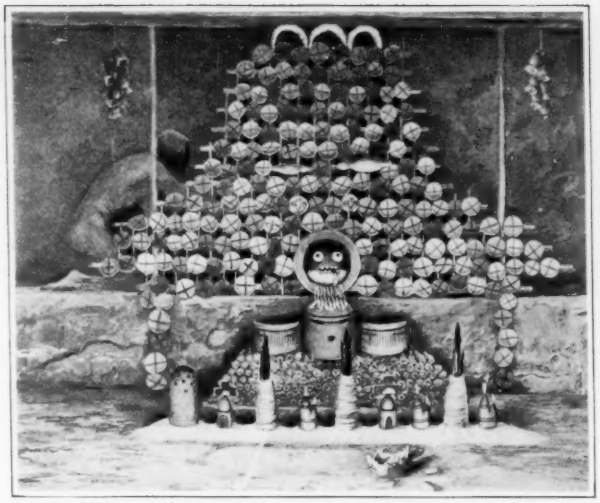
Thus of the total energy contained in the glucose, a portion, determined by the value of the ratio between the initial and the final concentration, is transformed into mechanical labor while the remainder is set free in the form of heat. These two portions vary in inverse ratio with respect to each other, but their sum total always remains equal to the total quantity of energy contained in the glucose consumed.

But it appears that this supposition contradicts what really occurs since experiment has demonstrated that the quantity of heat liberated augments with the work performed. But it is probable that the limits of variability are not sufficiently far apart to render evident this relation between the two portions of the energy.

Furthermore, we shall understand the purpose of the variability of the ratio between these two portions of the energy when we reflect upon the exceedingly great variability of the needs of the organism. In this manner the nervous system is capable of satisfying these widely varying needs of the organism. This variability is capable of explaining also the possibility of improvement in the animal machine as to the useful work done (the yield) by means of functional gymnastics. The non-consumed glucose becomes fixed in the muscle in the form of glycogen constituting here a store of chemical energy. This deposit is capable of satisfying the requirements both of muscular labor performed by the organism and providing for its calorific needs by means of the combustion of the glucose derived from the glycogen. In the case in which the glycogen undergoes direct combustion, *i.e.*, without being transformed into glucose the available chemical energy is transformed completely into heat because the action of the glycogen from the osmotic point of view has no effect. But when the chemical process becomes more intense, *i.e.*, when the quantity of glucose consumed is greater, the two portions of the energy available will increase at the same time.

Moreover, it seems that this view is confirmed by experiment since whenever there is an increase in the amount of work done the temperature also increases. If this is the true explanation of the matter the heat produced in the organism can no longer be considered a mere excretion which was later adapted to the purpose which it now fulfils. It must, on the contrary, have been designed from the very beginning to perform a definite function quite as important as the muscular function.

The term *excretum* as applied to heat would be justified solely in the case of the heat which inevitably results from all labor which is sterile from the mechanical point of view. Furthermore, this theory of heat as an excretion is not accepted by all physiologists. Professor Athanasiu of Bucharest holds that from the chemical energy contained in the glucose there issue originally all the forms of energy observed in the organism. He holds contrary to Chauveau's theory that heat also results from the same deposit of potential (chemical) energy without passing through the intermediate stage of physiological labor. According to this savant the supposed intermediate form of energy termed physiological labor is neither necessary nor logical, and as a consequence heat does not deserve in all cases to be designated as an *excretum*. It is this difference between the two views of the matter held by Chauveau and by Athanasiu which form the point of departure as the interpretation given above.



STRUGGLE OF SERPENTS AND MUDHEADS, ONE INCIDENT OF THE VERNAL EQUINOX OBSERVANCES

ALTAR ON WHICH THE WINTER SOLSTICE CEREMONY IS CARRIED OUT AT WALPI

Sun Worship Among the American Aborigines

The Ceremonies Attached to the Deification of the Orb of Day

By Webster P. True

THE passing centuries have drawn a veil over the life and customs of the American aborigines, and it is only as this veil is torn aside by the work of the archeologist that we begin to see the purpose and meaning of the fantastic ceremonies and religious rites of these earliest Americans in the misty dawn of history on this continent. And yet this very veil of mystery and uncertainty surrounding the past arouses the interest and stimulates the imagination, though no flight of imagination can exceed in weirdness certain of the ancient rites of the cliff dwellers of the southwestern United States, especially in the various forms of their worship of the sun. It is in large measure to Dr. J. Walter Fewkes, chief of the Bureau of American Ethnology of the Smithsonian Institution, that we owe our present knowledge of the prehistoric American cliff dwellers, and in the course of his thirty years of archeological research he has uncovered many ruins of these ancient communal cliff houses, and has brought to light a great amount of knowledge concerning the customs and religious practices of the Indians of the Southwest. It is especially with sun worship among the Hopi Indians that Dr. Fewkes is concerned in the last issued report of the Smithsonian Institution.

One method of arriving at the real meaning of the mysterious and involved ceremonial practices of the civilization which rose, flourished, and passed away among the cliffs and canyons of the Southwest long before the white man had penetrated thus far into the new continent, is by a close and scientific study of the surviving rites and religious beliefs of the present-day Indians, which, though modified somewhat through the centuries, still retain much of the early myths and rites. It is this method which Dr. Fewkes discusses in his most recent study of sun worship.

To begin with, it appears from a study of the ceremonies that the religion of the Hopi Indians is chiefly for the purpose of securing for themselves sufficient food and other blessings of this world. They worship the power that causes the rain to fall on the earth, for without rain the maize or Indian corn, their chief food resource, withers and dies, leaving them practically without food. Their observations of the sun early led them to know accurately by its position when the time was ripe for corn planting and when the rainy season, necessary for its growth, might be expected. Thus climatic conditions —rain, drought, cold, and warmth—were the foundation of their worship of the sun, and the supernatural power back of the earth and sky, respectively fertilizing the seed and enabling it to grow to maturity, was a magic force which must be worshipped, placated, and sometimes even compelled by magic to act favorably for the assurance of a food supply. Naturally there are many forms of this sun worship, but underlying all is the primitive realization that there is a power back of the sun which controls conditions of climate, and it is the various representations and symbols of this power which are exalted by the Hopi and other Indians, and to which are dedicated the complex of rites and ceremonies making up sun worship.

The representations are weird and often theatrical, as for example the elaborate rite of "calling back the sun," which occurs among the Hopi near the end of December. The Sun priests have for weeks been anxiously watching the sun go down over the horizon, receding daily farther and farther toward the south, until it seems to the watchful Indians that it must surely intend to withdraw permanently. At last, however, it reaches its furthest southern point and the announcement is made publicly that the sun has gone to his home in the west. Now must the great effort be made to bring the sun back to his people. The stage is set in one of the ceremonial rooms or kivas, occupied only by the sun clans and sun priests, mostly old men, and the principal rites are held here in secret. A screen is erected near one end of the room through the center of which is thrust the head of a serpent effigy, and in front of which are spread various symbolic materials, most prominent being a stack of ears of corn from which the future seed will come. In front of the screen stand masked men representing supernatural beings, and around the walls sit the chorus who during the ceremony sing weird songs and accompany them with rattles. When the priests have smoked the ceremonial pipe, events begin to happen. A step is heard on the roof of the kiva, and soon the Sky god announces his arrival by throwing a ball of sacred meal through the opening in the roof. Cries of an eagle produced by means of a bone

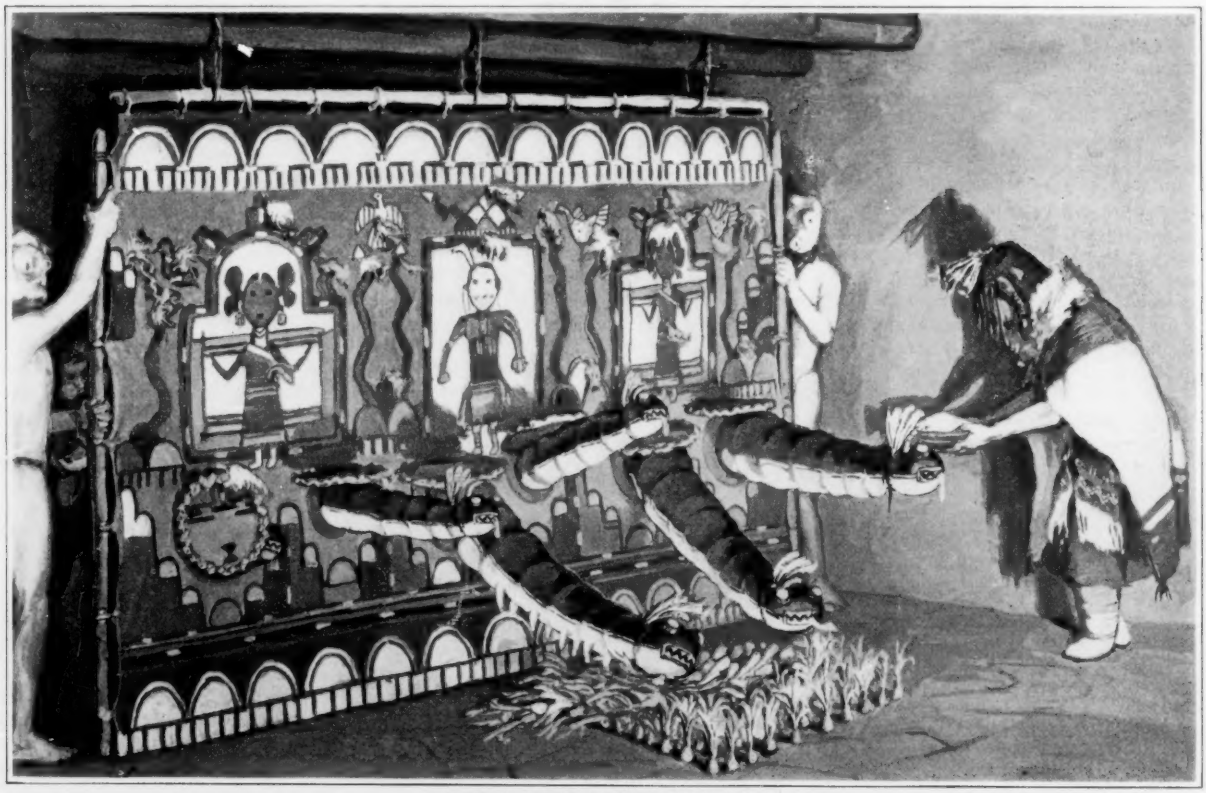
whistle are meant as an invitation for the god to enter, and soon he descends into the kiva. He is elaborately dressed to represent a bird, his head and body being covered largely with feathers, and more feathers are attached on a string across his shoulders to represent wings, which he flops up and down.

Having strutted around the room several times imitating a bird, he walks directly up to a maiden seated in one corner who represents the Earth maid. In front of her is a pile of sand in which are sticking several arrows. The Sky god, bending his body almost to the ground, grasps an arrow in each hand, straightens up with a loud cry, and quickly hurls them back into the sand. This is repeated several times, and the meaning, plain to see, is the call of man to the god to make fertile the earth, represented by the Earth maiden, by means of the lightening, symbolized by the arrows. During the numerous circuits of the room made by the Sky god in the course of this ceremony, he receives many prayers from the assembled priests, and the purpose of the imposing rite is not only to call back the sun, symbolized by the appearance of the Sky god, but also to urge the sky power to fructify the earth that the Indians may have abundant crops.

The horned or plumed serpent mentioned in the ceremony above is a personation of the Sky god and is worshipped in conjunction with the Sun god. This sacred serpent plays a prominent part in the series of weird dramatizations which take place among the Hopi at the time of the vernal equinox, and which are probably the most remarkable series of religious ceremonies ever witnessed among any tribe of the American aborigines. The performance takes the form of a series of acts, and the stage is prepared nearly as described above. The spectators are ranged about the walls of the sacred room, and the kiva chief is crouched over the ceremonial fire, feeding it from time to time with sticks of greasewood, and covering it with a blanket to produce darkness when it is necessary to change scenes. A tramping is heard on the roof of the kiva as before, and on being invited to enter, a number of men descend the ladder into the darkened room. They are busy with their paraphernalia for a short time, and when the fire is again allowed to light up the room, there is disclosed to the spectators a cloth screen containing many symbolic designs, the most conspicuous being six discs across the screen on which are painted symbolic pictures of the sun. The participants in the ceremony are a number of naked Indians called Mudheads on account of the strange masks they wear, which consist of a case over the head studded with knob-like projections over the eyes, mouth, and ears, giving them the appearance of some strange, uncouth animal.

At once, a chant is begun by these men, the six sun discs swing open, and from each opening comes out the black head of a serpent effigy manipulated by a man behind the screen; one, larger than the rest, called the "mother serpent." As the chant goes on, the serpents sway their heads and bodies fiercely from side to side, attempting to bite one another, while from back of the screen comes a roaring sound, the fancied cry of the horned serpent. The song rises louder and higher, and the serpents sway faster and attack each other more and more viciously. Suddenly at the height of the clamor, the "mother serpent" sways her body to the floor and attacks the imitation corn field consisting of little cones of clay with a corn plant in each. These are knocked down and scattered about the floor, and at once the serpents raise their heads, and a man dressed as the Earth woman offers them food in the form of sacred meal. The serpents are then drawn back through the screen, the kiva chief gathers up the scattered corn plants and passes them around to the spectators. This weird act undoubtedly represents dramatically the fertilization of the corn by the Sky god, personated by the horned serpent effigy. It is only one of six similar acts in this elaborate sun worship drama.

Thus in their ceremonial rites the Hopi dramatize various events connected with the sun in an effort to cause him to make fertile the earth and insure for them an abundant harvest. In certain other rites the struggle against hostile super-



THE SERPENT SCREEN AT WALPI

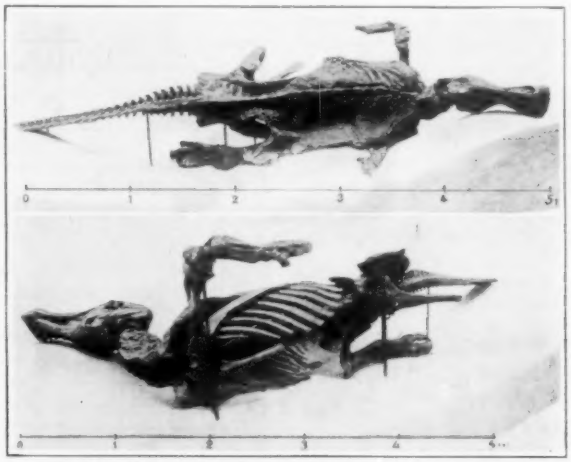
natural powers is represented, as for example those powers whose malign influences cause the growing season to be too wet or too dry for the best yield of corn. In one of these rites, the struggle is dramatized by actual conflict between men dressed to represent these supernatural beings, which take place secretly at night in the sacred kiva. One man representing the beneficent power of the sky and displaying on his shield the Hopi Germ god, stands alone before the altar, while his opponents, bearing shields with various other emblems, stand in two rows on each side of the room. As these men personating the hostile powers surge up against the supernatural being alone in the center, a chorus begins a low, weird chant which, as the contest waxes fiercer, increases in volume and tone until it becomes a wild war cry. Suddenly one of the hostile powers separates himself from the mass and engages in individual conflict with the Germ god shield bearer. These two combatants are locked in furious struggle for some time, until finally the attacker is overcome and falls to the ground exhausted, in which condition he is carried out. Another and another take up the attack amid great shouting and excitement, and each is overthrown in turn until the lone man stands victorious. Holding his shield high over his head and uttering a prayer symbolizing victory, he leaves the room as the excitement subsides.

On the morning after this victory over the hostile powers of the sky, there enters the pueblo a masked man dressed to represent the Sun god and wearing his symbols. He is accompanied by two men dressed as women, who carry trays containing ears of corn arranged in a circle, within which are symbols of sprouting plants. These three persons, representing the beneficent power of the sky, pass through the village, presenting to the head of each clan one of the sprouting plant symbols. Thus do the Hopi dramatize their effort to thwart the evil powers and encourage the Sun to fructify the earth and bless them with a rich corn crop.

Many of the secular customs of this tribe illustrate their recognition of the power of the sun and its influence over their lives. When a babe is born among the Hopi, a scratch is made on the wall of the house by its mother for each day from the date of its birth until the twentieth day is reached. The time is then ripe for the impressive ceremony of consecrating the new life to the sun and giving it a name. The rites begin about four o'clock of the following morning, when the room is thoroughly cleaned and the baby carefully washed. Its face is then covered with sacred meal and an ear of corn is fastened on its breast. This corn represents symbolically the mother of the child, and it is carefully kept during its life. As the time for the sunrise draws near, the baby's father seats himself on the roof of his dwelling facing the east, and covers himself with a blanket, leaving only his face exposed. He gazes steadfastly toward the east, and as the first light from the rising sun appears, he gives a signal and a procession comes forth from the room with the mother in the lead, followed by the grandmother carrying the baby in its crude cradle. As the mother advances across the roof toward her husband, she leaves behind her a straight trail of sacred meal, and the grandmother following holds the child so that its head stays directly over this line. This act symbolizes the desire that the child's life may be morally straight, and may never deviate from the line drawn symbolically by its mother. The head of the slowly-moving procession reaches the father just as the sun himself appears over the horizon, when the grandmother holds the baby up and its mother repeats a prayer consecrating her baby to the sun, the "father of all life," and pronounces the name which she has selected for it. The procession then returns to the house where a feast has been arranged.

Various other rites connected with their reverence of the sun power are performed during the life of an individual, and even at death he is buried looking toward the rising sun, and is addressed as follows: "You have become a Katcina. Aid us in bringing the rain, and intercede with the gods to fertilize our farms."

"In individual rites from birth to death," says Dr. Fewkes, who has himself witnessed most of these weird ceremonies dedicated to the Sun, "the worship of the Sky god, in the form of the Sun god, is always present in the Hopi mind, as well as in their great dramatic ceremonies."



TOP AND SIDE VIEWS OF FRANKFORT'S MUMMIFIED DINOSAUR, WITH A SCALE IN METERS (APPROXIMATELY YARDS) INDICATING HIS SIZE

A MUMMIFIED DINOSAUR

THE vast ice fields of Siberia have in many instances acted as a natural cold-storage plant for the preservation of the flesh of the mammoth, this prehistoric cousin of the elephant having been dug out of his chilly grave intact on numerour occasions. It has always been supposed, however, that this was the only instance in which anything more than the bare bones of the fauna of past geological epochs had come down to us. Doubtless the mammoth will continue to stand unique in this respect; but he is no longer unapproached. There has recently been put on exhibition in the Senikenberg Museum, Frankfort-am-Main, a dinosaur skeleton which carries with it a considerable portion of the skin of the animal, in mummified form. In particular the epidermis over the animal's back is present practically intact. The skeleton has been mounted in flying position, and makes altogether an impressive exhibit, as our illustrations with the meter-scale sufficiently suggest.

ELECTRONIC AMPLIFIER FOR LOW ANODE VOLTAGE

E. RUCHARDT (*Jahrb. d. drahtl. Tele.*, Jan., 1920), describes experiments carried out at Würzberg University on a special type of thermionic valve characterized by its small dimensions and by the filament being placed *between* the two plate-electrodes corresponding to the normal grid and anode. The theoretical considerations of this form of valve are dealt with according to the methods of Barkhansen, and the usual grid-voltage anode-current curves are illustrated. These show that in its final form, better results than with a normal 90-volt amplifier are obtained by this valve with 13 or 20 volts anode current.

Various schematic representations for the use of this valve in two-valve amplifiers are illustrated and the amplification variation with frequencies from 400 to 1160 cycles are tabulated. The chief value of this valve, experiments on which were discontinued at the end of the war, is that it permits of a considerable reduction in anode voltage as compared with the normal valve.

The Ciphers of Porta and Vigenére

The Original Undecipherable Code, and How to Decipher It

By Otto Holstein

THE origin of Cryptography is lost in the mists of the past. The earliest use made of Ciphers, to our certain knowledge, was by the Spartans long before the Christian era. Its origin is probably contemporary with that of the art of writing itself since there was hardly a time when the need or desire for means of communicating intelligence secretly did not exist.

Ciphers were employed in the days of Cæsar and we have definite knowledge of the systems then in use. During the Renaissance cipher communications reached their most extensive use and most of the intrigues of those days were conducted by secret communications and many actual examples thereof are still extant and these have furnished material for the later day cryptographer to exercise his skill on.

Who has not read Poe's "Gold Bug" and who has not marveled at the almost supernatural acumen that appeared to operate in the solution of the secret communication that betrayed the hiding place of the treasure?

Until the 16th century ciphers were more or less simple in their construction and operation, although probably adequate for the purpose for which they were employed. In the year 1563, however, the Neapolitan physician Porta evolved and described the first cipher whose operation depended upon the use of a key-word, key-phrase or group of letters, agreed upon and changeable at the will of the correspondents. Twenty-three years later, in 1586, the French physicist Blaise de Vigenére brought out a system identical in results with that of Porta but somewhat more simple and more easy to operate.

The Cipher of Vigenére which is more commonly known as the "Alphabetic Square," the "Russian Square," the "Multiple-Alphabet Cipher," etc., takes the following form:

As the working of the system may best be explained by example, let us take for our key, say, the word CIPHER and, given the example: CIPHERS EMBRACE ALL MEANS WHEREBY WRITINGS MAY BE TRANSCRIBED IN OCCULT TERMS, the communication may be prepared for encipherment by being written out in the usual manner, the key-word being written above, letter over letter, thus:

CIPHERCIPHERCIPHERCIPHERCIP etc.
CIPHERSEMBRACEALLMEANSWHERE

or, a better plan still, the key-word is written and below in columns—equal in number to the letters of the key-word—the text to be enciphered, leaving space under each line for the cipher letters as found, thus:

C I P H E R
C I P H E R

S E M B R A

C E A L L M

etc.

This latter system offers the advantage of permitting each column to be enciphered with the corresponding alphabet in turn—an advantage that will be better appreciated in practice.

The communication having been thus prepared, the Vigenére Table is referred to and the first letter of the key-word ("C" in our example) is found in the top horizontal line and the first letter of the communication (likewise "C" in this case) is found in the vertical column of capital letters at the extreme left of the table and the letter in the table at the intersection is taken as the cipher letter ("e" in the present instance). The reverse of this process, *i.e.*, locating the key-letter in the left hand vertical column and the plain-text letter in the top horizontal line will give identical results, as trial will prove. Proceeding in like manner "I," the second letter of the key, and "I," the second letter of the communication, give "q" as the cipher equivalent; the third letter of the key, "P" and the corresponding letter of the plain text, "P" give "e" as the third cipher letter and so on, the enciphered communication appearing as follows:

EQEOI IUMBI VREMP SPDGI CZAYG ZTICN TQIQR XUUPF FVVZP UWTTQ QLHZP WRJYC VBTYQ JXXXX.

The enciphered communication is invariably written in groups each of an equal number of letters which serve as a check to the receiver (when transmitted by telegraph, radio, telephone, visual signal or the like). The four final letters "X" being added to fill out the last group to the requisite number of letters. Likewise, in the light of what is to follow, it would obviously be playing into the hands of the decipherer if the original word grouping of the letters (EQEOIIU MBIVREM PSP DGICZ AYGZTIC, etc.) were preserved or if the communication were written in groups corresponding

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
A	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z
B	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a
C	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b
D	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c
E	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d
F	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e
G	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f
H	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g
I	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h
J	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i
K	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j
L	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k
M	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l
N	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m
O	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n
P	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
Q	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
R	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q
S	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r
T	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
U	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t
V	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u
W	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v
X	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
Y	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x
Z	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y

THE VIGENÉRE TABLE

to the number of columns in which it was enciphered (in this case EQEOII UMBIVR EMPSPD, etc.) so the communication is broken up into arbitrary groups, each of a given number of letters, for the purpose of disguising the word forms as well as the number of letters in the key-word and to serve as an index to the receiver, as has been explained.

To decipher a communication, being in possession of the key, the key-letter is found in the top horizontal line of the table and the column at the top of which it is found is traced downward vertically until the corresponding letter of the enciphered text is located, then tracing along the horizontal line so located in the table to the extreme left, the letter appearing thereat will be the plain-text letter. In the case of our enciphered example, "C," the first letter of the key-word is found at the top of the third column, tracing down this column until the first letter of the enciphered communication "E" is located and following the horizontal line so located to the extreme left of the table the first plain-text letter "C" will be found.

To this point and no further extends the knowledge of the average person who knows something of ciphers but who has not made the subject one of deep study and analysis. The most remarkable views are held regarding the absolute security of this particular system! The champion of this and like systems at once points to the fact that in ciphers of the simple substitution type (Poe's "Gold Bug" cipher belongs to this class) where a letter of the plain-text is represented in the cipher by another letter, which always remains the same, solution is made more or less easy by the application of the well-known rules of letter frequency. He points to the fact that, taking our own example for the purpose of demonstration, E, the most frequently occurring letter in the average English text, is represented at its first occurrence by I and on each of its subsequent eight recurrences by M, M, G, G, T, V, I and T in the order shown; T, the second letter in English in point of frequency, by I, V, V and B and so with the other letters of the plain-text whose cipher equivalents follow the same eccentricity.

How then—asks the incredulous one—can such an example be solved?

But before we proceed, let us return to the popular misapprehension, the delusion regarding the invulnerability of this system which is so firmly fixed that we come in contact with statements and articles describing it as "indecipherable" and some even refer to it as "new." I have in mind an article published in the Proceedings of the Engineers' Club of Philadelphia and reprinted in the SCIENTIFIC AMERICAN SUPPLEMENT (No. 2143) of January 17, 1917, entitled "A New Cipher Code," in which our old and well-known Vigenére table appears as the subject of an interesting if somewhat erroneous article. The author's closing paragraph is of especial interest and is quoted herewith:

"The method used for the preparation and reading of code messages is simple in the extreme *and at the same time impossible of translation unless the key-word is known.* The ease with which the key may be changed is another point in favor of the adoption of this code by those desiring to transmit important messages *without the slightest danger of their messages being read by political or business rivals,*" etc.

The italics are ours!

A similar article, in Spanish, treating of the same system appeared in a weekly paper of one of the South American capitals (*VARIEDADES*, Lima, Peru, October 20, 1917). Similar claims were made as to the "indecipherability" of communications enciphered by the system under discussion.

That the conclusions of the authors of the respective articles are in error will be shown.

In any problem the first thing to engage attention is how it functions and then to reverse the process in the hope of undoing what has been done. How many of our readers are familiar with Poe's statement which is, in effect, that "what human ingenuity can do, human ingenuity can undo!"

Returning now to our example, after this divergence, we note that although given letters of the text are represented by a variety of other letters in the cipher when they are enciphered by different letters of the key-word, each letter of the plain text when enciphered by a given letter of the key-word invariably takes the same cipher equivalent. Note, for example, that C of the foregoing example when enciphered by the key-letter C is represented by E on both occurrences; S by U on both occurrences; E by G each time it occurs; R by T both times and T by V on each occurrence. This is, in effect, equivalent to the letters falling in this column being enciphered by the "C" of third alphabet. Likewise of the letters enciphered by the letter I of the key-word, I of the plain text is represented by Q on each of its three occurrences; E, which was represented by G in the preceding alphabet is represented by M on both of its occurrences in the present instance. Thus all of the letters enciphered by means of the key-letter I of the key-word, are enciphered by the "I" or ninth alphabet of the table and so on throughout the example.

Now since we know that all letters enciphered by means of the same alphabet or key-letter always take the cipher equivalent it must follow that if we can ascertain the number of alphabets employed (the number of letters in the key-word) we can segregate the letters of the cryptogram into as many groups and that each group will constitute in effect a simple substitution example. The plain-text equivalents of its constituent letters can, if there are sufficient letters, be found in the usual manner of solving cryptograms of this type, that is, by making a frequency table of the cipher letters and comparing it with a normal frequency table.

But how—we are asked—are we to ascertain the number of alphabets employed in enciphering the example—in other words, how are we to know the number of letters in the key-word?

Simply enough! But here we must fall back on some of the facts we have learned from the study of what we may term the mechanics of written language. In solving Poe's "Gold Bug" cipher we learned that the letter E represents approximately 13 per cent of the letters in any average English text; T approximately 9 per cent; O eight per cent and so on. A table of letter frequency for an ordinary English text of sufficient length to give a representative frequency, represented graphically, would assume the following appearance:

A .....
B ...
C .....
D .....
E .....
F ....
G ...
H .....
I .....
J .
K ..
L .....
M .....
N .....
O .....
P ....
Q
R .....
S .....
T .....
U .....
V ..
W ...
X
Y ....
Z

(This table is based on a check of text two hundred letters in extent.)

But in treating with Poe's example we did not learn—for there was no occasion in his example for its employment—that not only do the letters in written English (and all other European languages for that matter) occur with a given frequency, but that letters combine one with another, to form syllables, terminations and words with a given and known frequency. For example, note in any English text the frequency with which "the," "than," "that," "their," "theirs, "them," "there," "they" and words such as "fourth," "fifth," etc., having -th as their suffix, occur. Words like "other," "and," etc., etc., occur with considerable frequency and terminations such as "-ance," "-ency," "-ion," "-ment," etc., inevitably occur, and a check of "bigraphs" as these two-letter groups are called, gives the following results, the bigraphs shown in the order of frequency: TH, ER, ON, AN, RE, etc., etc. What has been said of bigraphs applies to "trigraphs" or three letter groups and to other letter groups as well and the trigraphs in their order of frequency appear as follows: THE, AND, THA, ENT, ION, TIO, FOR, NDE, etc., etc.

Thus, in any text of any length, there must inevitably ap-

pear recurrences of such groups of letters and since we have learned that given letters of the plain text enciphered by a given letter of the key-word invariably give like results in the cryptogram, it must necessarily follow that such common bigraphs, trigraphs, terminations and words will often be enciphered by the key-letters in the same sequence which will produce as a result, similar cipher groups throughout the body of the enciphered communication and from these recurring groups the number of alphabets employed can be fixed to a certainty.

From this point the process of solution may be best explained by example: Given the following cipher communication which, from previous knowledge we shall assume to have been enciphered by means of the Alphabetic Square or Vigenére Table:

IXAIC CZLDI OXAIC RWJFW VWYEM EKUPR AYYFC
WAAIR HWASY NKTJR TWKDF EURRF EJLDC INLSX

The first thing that engages the eye of the expert in the foregoing example are the recurring groups AI, which occurs three times; AIC, which occurs twice and LD which likewise occurs twice. Counting the number of letters between such recurrences, always including one of the groups in the count (*i.e.*, counting from the beginning of one group to the beginning of the same group of letters on its second or subsequent occurrence) we have:

AIC to AIC, 10 letters $= 2 \times 5$
AI to AI, 10 " $= 2 \times 5$
AI to AI, 25 " $= 5 \times 5$
LD to LD 55 " $= 5 \times 11$

The key-word may contain 2, 5 or 11 letters but since 5 is the dominant factor it is probable that a key-word of five letters was used in enciphering the example and we proceed to divide the communication into groups, five in number, taking the first, sixth, eleventh, sixteenth, etc., letters for the first alphabet; the second, seventh, twelfth, etc., for the second alphabet; the third, eighth, thirteenth, etc., for the third alphabet; the fourth, ninth, fourteenth, etc., letters for the next alphabet and the fifth, tenth, fifteenth, twentieth, etc., letters for the last alphabet and when this has been accomplished a frequency table is made for each of the groups, which assumes the following appearance:

I	II	III	IV	V
A .	A .	A	A	A
B	B	B	B	B
C .	C	C	C	C ....
D	D	D	D ...	D
E ...	E	E	E .	E
F	F	F	F ..	F ..
G	G	G	G	G .
H .	H	H	H	H
I ..	I	I	I ...	I .
J	J .	J .	J .	J
K	K ..	K .	K	K
L	L	L ...	L	L
M	M	M	M	M .
N .	N .	N	N	N
O .	O	O	O	O
P	P	P	P .	P
Q	Q	Q	Q	Q
R .	R	R .	R .	R ...
S	S	S	S ..	S
T .	T	T .	T	T
U	U .	U .	U	U
V .	V	V	V	V
W .	W	W	W	W
X	X ..	X	X	X .
Y	Y .	Y ..	Y	Y .
Z .	Z	Z	Z	Z

While the example is a very short one from which to expect representative frequency tables, factors to aid us in fixing the plain-text equivalents of the cipher letters in each of the five alphabets: (1) The letter frequency and (2) what is known as symmetry of position, that is, the position of one letter in the alphabet with relation to the others, when it is known that normal or A, B, C, sequence alphabets were used (which is the case when the Vigenére table is used) thus, in the first table E plainly represents itself both by reason of its frequency and its relative position with respect to the other letters which are shown as having occurred in that alphabet. In the second frequency, W, for the same reason is plainly the equivalent of E in the plain text. In the third frequency A might equal E, being the most frequent letter, but in this event the other letters correspond to what we expect since in this event L, which occurs three times would equal P and we would hardly expect that number of P's in a text of fourteen letters so we change to the theory that A must represent one of the other frequent letters of the alphabet—probably T—and assume that L, occurring three times, is the equivalent of E which would then make A the equivalent of T, which agrees with what we have reason to expect. In the fourth table F equals E and in the fifth C equals E.

Turning now to the Vigenére or Alphabetic Square, we find that E equals itself in the first alphabet of the square; W equals E in the nineteenth alphabet; L equals E in the eighth; F equals E in the second and C equals E in the twenty-fifth alphabet. With this knowledge it is an easy matter to fix the values of the remaining letters of the five alphabets and the communication may be deciphered directly by reference to the alphabets in question, or by noting the equivalent of the letter A in each alphabet the key-word—a knowledge of which is not at all essential—may be ascertained and the cryptogram deciphered in the usual manner.

The key-word is ASHBY and the communication, deciphered, reads: IF THE CHECK OF THE RECEIVER DOES NOT AGREE WITH THE TRANSMITTED CHECK THE RECEIVER, etc., etc.

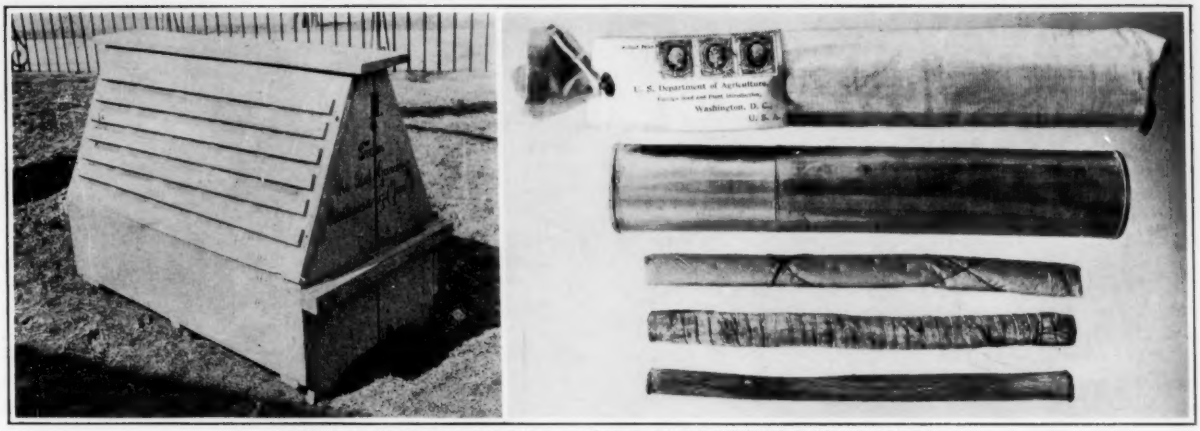
It may be claimed that the process of solution is labored or complicated but this is not so, it is comparatively simple and it must be taken into consideration that many of the steps gone into at length, for the sake of elucidation, are either ignored or performed almost mechanically under other circumstances.

This is but one of a number of methods by means of which ciphers of this type may be solved.

It may be frankly admitted that a very short, isolated communication enciphered by means of the Vigenére table may remain *undecipherable*, but one of any considerable length or a number of short communications enciphered by the same key would not long remain secret and since a practicable cipher must anticipate such employment, examples of this type would not perplex the expert for any great length of time.

TRAINING THE CHEMICAL ENGINEER

AT the recent meeting of the Institute of Chemical Engineers the Committee on Chemical Engineering Education made a progress report, the statistics of which are given in full in the June 15th number of *Chemical and Metallurgical Engineering*. It is, indeed, surprising to find such a wide variety of subjects prescribed in the courses of some seventy-five educational institutions. The total number of different courses are something over two hundred and thirty and in the list one finds some rather unexpected topics as, for example, Irish history. There is no doubt that standardization is needed even though some of the institutions must offer specialties, as for example, sugar in Louisiana, paper in Maine, and ceramics in Illinois. The chairman of the committee, Dr. Arthur D. Little, 30 Charles River Road, Cambridge 39, Massachusetts, is desirous of receiving any communications relative to the subject as the committee wishes to continue its work and do what it can to improve the situation. Those particularly interested in the subject will do well to study the tabular matter in the article to which reference is made.



THE TRAVELING QUARTERS OF SOME OF OUR IMMIGRANT PLANTS

Left: Portable greenhouse packed for shipment of a large plant. *Right*: A sample cutting and the way it is put up and mailed to the Department of Agriculture

Plant Immigrants to the United States

Where They Come from and the Precautions That Surround Their Naturalization

By S. R. Winters

CONGRESS and the immigration authorities are wrestling with the problems incident to the restriction of the tidal wave of foreigners who disembark at Ellis Island lest the character and magnitude of the influx unduly disturb the melting-pot process of Americanization. Similarly, at Washington, the Office of Foreign Seed and Plant Introduction, United States Department of Agriculture, is cognizant of its responsibility involving strict supervision of plant immigrants admitted into this country. Laxity in preparing consignments of rare seeds and plants collected from the remote corners of the earth, thereby introducing a scale insect or parasitic disease, would menace the plant industry of America.

Pickled mumes from Japan; wild alfalfas from Chinese Turkestan and Siberia; dwarf almonds, cherries and apricots assembled in Russian Turkestan; bamboos and strawberry trees from the south of Shanghai; rare vegetables discovered in Portuguese West Africa; potatoes from New Zealand; grasses from the Mediterranean region; durum wheats from Russia—such, in brief, afford a glimpse of the wide ramifications of the explorer whose life is dedicated to wandering in unfrequented areas in search of plant life for culture in this country. All told, 51,000 specimens of seeds and plant cuttings for propagation have been introduced in America within a period of 22 years. The vastness of the collection, obviously, entailed the importation of hundreds of worthless plants and others whose value yet remains to be determined. Still others, where the process of experimentation has been unerringly applied, have established their intrinsic merits even beyond the expectations of the enthusiastic agricultural explorers. Durum wheats, rice, Sudan grass, feterita, alfalfas, grasses, citrus fruits and sorghums are notable illustrations, the brief recital of their names suggesting a wealth of plant life.

From the mule-drawn cart, laden with its cargo of rare plants, treking through the sandy deserts of Africa to the cosmopolitan life of Washington, with its modern facilities of transportation, is a far cry. Shipping imperishable products half-way around the world is a risky undertaking, to say nothing of consigning living plant material to a journey of thousands of miles. Seed, cuttings or scions, and rooted plants, are the media employed for introducing growth into the United States from the far-away places of the globe. The wild life which formerly characterized many of these plants lends further interest in the methods which involve their subjection, consignment, and subsequent submission to the taming process which they undergo hereabouts.

Seed is the easiest and safest way of contact between the native home of the parent plant and the country of its adoption, with thousands of miles intervening. Ripe, unmixed seeds are essential. They are dried, subjected to the influence of shade rather than a bright sunlight, and where it is impracticable to clean them in the field the renovating process is administered on their arrival in Washington by the seed-cleaning machinery of the Department of Agriculture. The vitality of seeds varies quite as widely as the mortality of the human family—they may die within a few days if dried out or retain their power of germination for a quarter of a century. Small-sized seeds, like grass, melon and vegetable seeds are shipped dry in sacks or envelopes. Chestnuts, palm and seeds of fruit trees—as well as other larger growths having oily kernels—are packed in slightly moistened charcoal, the latter preferably having been washed to remove the creosote. Sphagnum moss, which is barely moist, likewise answers this purpose. Mango and mangosteen seeds, and other short-lived varieties are subjected to a moistened mixture of half charcoal and an equal part of chopped moss. Seeds extracted from fruits are washed, the adhering pulp is removed, and the seeds are dried in the shade before packing in charcoal. Otherwise molds originating in the fragments of decaying pulp may penetrate the living seeds. The risks imminent from molding are lessened by washing the packing material in two per cent formalin and then sousing in boiling water.

Seeds are not easily obtainable and not infrequently they are untrue to the parent stock in their reproductive capacity. Cuttings and scions—the former consisting of roots and the latter products of grafting—are appropriated with varying degrees of success. They are judiciously selected with regard to the perpetuation of a vigorous growth, devoid of scale insects or disease spots that not only would retard their own development but probably menace other plant life. The diameter of the cutting varies, plantsmen admitting that large specimens carry better than slender ones. A cutting or scion is taken from a portion of the branch which has completed its first season's growth, having not yet attained two years of age. Deciduous trees and shrubs are robbed of their

offspring after the leaves, operating by gravitation, have clustered on the ground. Cuttings of soft-wooded plants, for instance geraniums, are frequently unable to withstand the brunt of long-distance journeys. Decay is a foe of tender offshoots. Scions of the orange or plants with evergreen leaves can be subjected to the captivity of the agricultural explorer at any season of the year.

The ingenious but frank postal official of the Washington, D. C., post office, who in cautioning the pre-Christmas patrons to "Wrap with Care if You Care a Rap," issued an injunction which has virtue in the transportation of plant immigrants. Verbally, the instructions of the Office of Foreign Seed and Plant Introduction may not be so emphatic, but in supplying mailing containers its directions to agricultural explorers are of a positive character. Tin tubes have proved most satisfactory as mailing containers. The tin is removed from the mailing bag, it is opened and the dry sphagnum moss displaced. The cap is filled with water up to a small hole in it, the contents then being sprinkled over the moss. The latter is mixed until a uniform degree of dampness is evident. The mixture is deposited at one corner of the waxed paper which is enclosed in the tin. Forthwith the cuttings or scions, from three to six in number, depending upon their size, are placed on the moss, covering them lightly therewith. The corner of the paper is folded down, the cuttings and moss are rolled in the paper just tightly enough to permit of their encasement in the tin, and the side corners of the paper are folded in under the roll.

One of the special obligations devolving upon the explorer in his quest of rare growth is to supply data for recording in printed form the description of the plant and any history concerning its culture. Consequently, at this juncture of the mailing procedure the name of the plant, its variety, designation, the date and locality where collected, are written on a slip of paper and incorporated into the roll. The package is then inserted in the tin, the cap is placed on, and the tin given quarters in a sack. Postage required is pasted on the tag which accompanies each tin. The latter does not exceed 12 ounces, or 350 grams, in weight, and the rate of postage is equivalent to one cent per ounce or fraction thereof. The name and address of the sender appear on each tag, which insures quick identification of the shipment when it reaches Washington. The tins are retained in cool places in transit on board the steamer. Labels on consignment bear the words "Foreign Seed and Plant Introduction, United States Department of Agriculture."

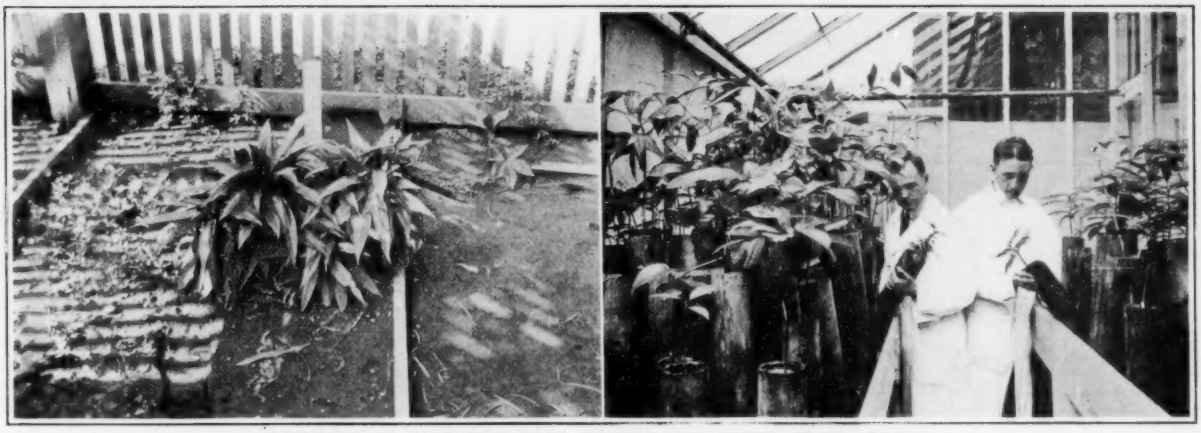
PEELING THE PHILIPPINE MANGO, NOW BEING GROWN IN CUBA AND SOUTHERN FLORIDA

Plants uprooted bodily from the soil of their nativity for long-distance hauls and subsequent transplanting are shipped in a sort of portable greenhouse. They are too bulky to send by sample post and are, therefore, forwarded by parcel post, express or freight. The plants are dug without injuring the numerous fibrous roots, and are packed in a ventilated box. A small wad of earth is left around the roots in the case of evergreen plants; the roots of deciduous trees are deprived of the adhering soil, moss being entwined about them as a substitute. The tops are unhampered, save in freezing weather when a cloak may serve as frost protection. Each plant is rigidly placed in the box so that it will not have room for acrobatic stunts. Ventilation, to be sure, is essential. Several one-inch holes, penetrating the region where the tops of the plants have quarters, afford sufficient air if they are on all four sides of the box. Recognizing that rats are not strictly land lubbers, each hole in the box of plants is covered with a strip of wire screen as a deterrent to invading pests. Plant shipments must be kept cool in transit, the box being stationed in what is described as the cool room (not the cold-storage room), where a temperature between 35 and 50 degrees Fahrenheit is maintained.

A specially-constructed portable greenhouse has been designed for the long-distance transportation of tender tropical plants. A substantial wooden box, having a strong bottom, is elevated from the ground by short legs. Handles are equipped at each end. The roof of the miniature house slopes, being composed of two glazed sashes, one of which is hinged at the ridge pole, thus permitting its uplift like a box lid. The glass is safeguarded by durable slats, ventilation being afforded by two holes, one at each end of the box in the vicinity of the ridge pole. Wire netting is a covering for these holes. Plants having quarters in these portable greenhouses are given light by occupying places on the deck of the steamer. An awning is a protection from salt spray and the salt water used in scrubbing down the deck, dosages which are injurious to foliage. Not unlike cattle in transit, plant life has to be watered at least once a week during the journey. Damp cocoanut fiber as a packing, however, will minimize the water requirements of plants.

Newly-imported plants, upon arriving in Washington, are subjected to rigid examination by inspectors of the Department of Agriculture. The surveillance of incoming plant specimens applies to rare budgets from diplomatic and consular officials as well as to new varieties of rice that have possibilities of contributing to the crop wealth of Texas and Louisiana. Smuggling is not countenanced, and the argus-eyed, white-aproned inspectors of Uncle Sam are tireless in their activities of detecting insects and parasites that would intrench themselves along with the vegetative growth seeking acclimation. An identification tag, as well as a history of the variety, quantity and origin of the material, are prepared for each package or container from abroad. Compilation of this information and preparing an inspection card precede opening of the nursery stock upon its arrival in Washington. Each introduction is numbered by the Federal Horticultural Board, supplementing the serial number previously assigned by the Office of Foreign Seed and Plant Introduction. Thus it is possible to keep tab on the particular specimen, both with respect to its performances in this country as well as in the old world.

Questionable seeds, cuttings, plants, buds, or bud sticks, or those harboring insects or diseases of any description, are either destroyed or subjected to disinfection and grown under observation in a specially screened quarantine greenhouse far



BRINGING IN VALUABLE FOOD PLANTS AND TREES FROM ABROAD

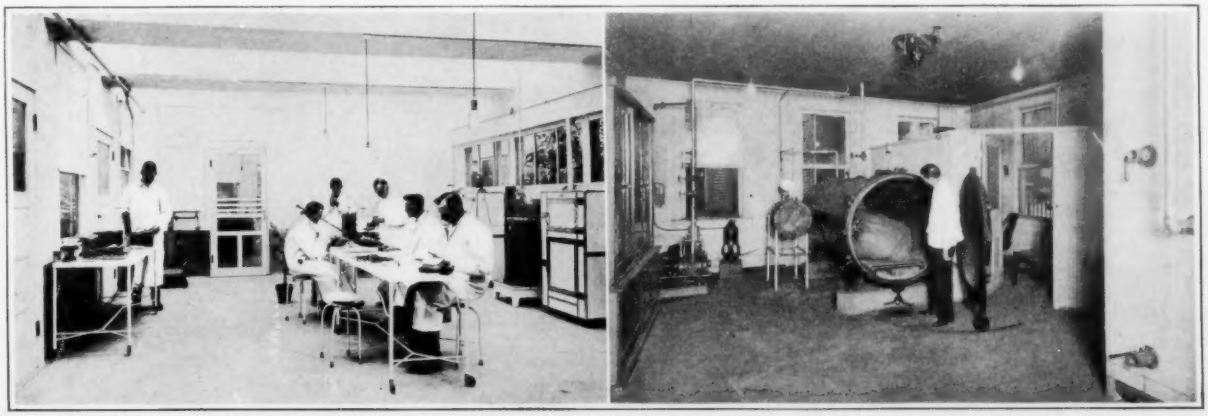
Left: A Chinese dwarf peach that produced seven fruits when but 15 inches high. *Right*: Inspecting plants that have been put under quarantine, to determine whether they may be freed of suspicion

removed from the area of cultivation. Other than periodical introductions of plants by the Office of Foreign Seed and Plant Introduction, there are other sources of importation which contribute to the duties of the inspection service. Diplomatic and consular officials, botanical collectors, travelers, missionaries, and amateur plant lovers abroad, seek admissions for their "finds" in foreign countries, ambitious of contributing to the plant industry of America. Seeds and bulbs are brought in for Congressional distribution, citrus plants and seeds are sponsored by the Office of Crop Physiology and Plant Breeding Investigations, and the Offices of Cereal Investigations and Forage Crop Investigations apply for admission in behalf of seeds of cereals and forage plants.

The necessity for inspection facilities is self-evident. The inspection house, maintained in Washington, is comprised of an inspector's office and room for examining the material. A high wire fence encircles this house, and the gates and doors are locked against outside intrusion. Special permits, expiring at the end of the day of issue, are given interested persons. *The office of the inspector is 12 by 19 feet in dimensions, having three windows, two skylights extending the width of* the room, and three doors, one of which opens into the inspection quarters. Furniture is conspicuously absent, only such units as those required to preserve the records being found. Nursery stock is not examined in this office.

Inspection of plant immigrants is negotiated in quarters 19 by 30 feet in size, the room having four windows, four skylights embracing the width of the room, eight ventilators, and four doors. The latter are screened with copper wire mesh, forty meshes to the inch. The floor and three feet of the walls are of concrete, while the remaining portion of the walls is constructed of galvanized iron. This manner of construction permits of flushing or syringing of the floor and walls with water or a disinfectant without harmful effects. Furnishings of the inspection quarters are more lavish than those of the inspector's office, including: Five white enameled tables on wheels on which are deposited specimens subject to examination, four white enameled stools, three white enameled refrigerators for safeguarding perishable plants, a small sterilizer, stove, sink for washing the hands, scales, and white enameled trays for sterilizing small portions of seeds or cuttings with bichloride of mercury, and one white enameled bucket containing a weak solution of bichloride of mercury for washing the hands after handling material suspected of being infected with insects or diseases. Long white coats are the distinguishing characteristics of inspectors, raiment invariably worn when inspecting immigrants of the plant world. Soiled coats are retained in a galvanized iron bucket until *disinfected and laundered. Inspection quarters are daily cleaned and fumigated or washed down with formaldehyde* as the demands may warrant.

Quarantine regulations of diseased plants are enforced with quite the precision that an attending physician would bring to the isolation of a patient inflicted with a contagious disease. Capacious is the quarantine greenhouse, being 70 feet long, 20 feet wide, and divided into 14 units, six of which are 14 feet by 7 feet 4 inches, and eight of which are 7 feet 8 inches by 7 feet 4 inches. A three-foot corridor extends the



MAKING SURE THAT NO PLANT PESTS ACCOMPANY THE PLANT IMMIGRANTS OVER OUR BORDER

Left: Room in which incoming material is examined to determine the presence or absence of disease. *Right*: Vacuum fumigating apparatus which gives some of the suspected plants a clean bill of health

length of the structure. Admission into a unit from the corridor involves passage through a vestibule 3 feet by 3 feet which is provided with two doors, one opening into the corridor and the other into the unit. Doors and ventilators are screened with copper wire. The ventilators are so arranged that they can be controlled from the corridor, thus obviating entrance therein for the purpose of regulating air chambers. Other than being screened, the ventilators open into the corridor and not directly out of doors. This arrangement is in the interest of protection of the plants from a strong wind and in making secure the insects whose discovery and effacement are to be accomplished according to scientific methods. Air is admitted in the corridor at the apex of the room by standard ventilators used on greenhouses. Adequate circulation of air is facilitated by equipping each unit with a small sliding window 10 inches by 16 inches, screened with copper-wire mesh. The sill of each window is eight inches from the floor. These various units retain their independence with respect to being fumigated separately. Object of quarantine, serial number, date of quarantine, name of specimen, origin, and prescribed treatment, are made the subject of permanent record.

The apparatus used for sterilizing plant and plant products consists of a fumigation chamber or retort, an auxiliary chamber or generator for the generation of gas and an air pump. One end of the chamber is permanently closed, while the other end is equipped with a stout iron door swung on a hinge and held in a fixed position by six clamps. The gasket, embedded in the door, comes in immediate contact with the flange of the retort and when greased and clamped is a bar to air entering the chamber during an exposure. This retort lies with its longest axis in a horizontal position. Four openings are in the upper side of the retort: The one nearest the door is provided with a vacuum gage, registering the degrees in pressure in units equal to inches of mercury; the second opening is fitted to an exhaust pipe which is attached to the air pump; the third opening is used to permit the air to enter the chamber at the completion of an experiment, while the fourth opening is fitted to a pipe which leads to the auxiliary tank or generator in which the gas is generated.

Plants and plant products to be fumigated are placed in the retort, the door closed and clamped, and the air exhausted until the gage registers 26 inches. Differently expressed, the air in the chamber is drawn out until the pressure is the equivalent of 5 inches of mercury. Here the suction is cut off, and the gas is generated in the auxiliary chamber and introduced into the fumigation chamber through a pipe. Gas may be generated in one of two ways. The cyanide may be placed in the jar within the generator, the door closed and the acid and water introduced through the tubulature; or the acid may be placed in the jar within the generator and the cyanide in solution introduced through the tubulature. Experience justifies the latter procedure as preferable. This is particularly true where a glass tubulature is employed, as it eliminates all possibility of breakage of glass by the heat generated from the combination acid and water. Material to be disinfected may be fumigated in either of two ways, namely, by generating the gas in the presence of a partial vacuum and holding the vacuum for a specified time, or by generating the gas in the presence of a partial vacuum and returning to normal atmospheric pressure upon the completion of the generation. Thus the possibilities of introducing a scale insect or parasitic disease that might menace the plant industry of America are minimized.

Historically speaking, how well has the plant immigrant assimilated itself in the melting pot of the plant industry of America? Only a few notable illustrations will be recited, the values of the plants enumerated being quoted as computations of the Department of Agriculture: Feterita, imported from Egypt in 1906, has an annual crop valuation of $16,000,000 in this country. Sudan grass, preeminently the forage crop of the South, has a commercial appraisement of $10,000,000. Durum wheats, products of Russia, made wheat production a factor in a hitherto non-growing area in the Northwest. The taxpayers were assessed a quarter of a million dollars to meet the expenditures incident to the importation, while the Department of Agriculture assesses the income from this investment as approaching $50,000,000, yearly. Navel oranges from Brazil gave to California its mammoth industry, involving the cultivation of 30,000 acres, a crop computed to be worth $15,000,000 annually. Bamboo groves, carpet grass, lespedeza, and alfalfa valued at millions of dollars, are cumulative evidence that plant immigrants are capable of acclimating themselves to plant life without being a disturbing influence in the seething melting pot of America.

SCIENCE AND COMMUNITY TRUSTS

IN the June 10th number of *Science*, R. M. Yerkes calls attention to community foundations or trusts of recent origin which have considerable funds at hand for scientific service or for research. The Research Information Service of the National Research Council has recently compiled available information concerning funds for research and if the funds at present listed as community foundations be added to funds listed in the Bulletin above mentioned it appears that there are approximately five hundred million dollars in American funds available for research in the natural sciences. Dr. Yerkes estimates that for the encouragement and support of scientific research through medals, prizes, graduate and research scholarships and fellowships between forty and fifty million dollars is spent annually in the United States.

The community trust idea appears to have originated in Cleveland where it began in 1914. This trust has grown to a foundation of approximately one hundred million dollars either given or bequeathed and following Cleveland's lead more than forty other American cities have organized similar trusts. The effort is to assure great security of principal, flexibility in the use of income and the prevention of obsolescence. There are numerous instances in the United States to illustrate the folly of making charitable gifts with fixed objects. Attention is called to the action of Benjamin Franklin who set aside a sum of money in his will to be used for the maintenance and benefit of a certain type of artisan, numerous at the time but no longer existent. As late as 1909 a fund of four and a half million was left for the benefit of full orphan or fatherless girls under such restricted conditions that already the point has been reached where only 114 girls are being cared for whereas the funds are adequate to provide for nearly a thousand.

The following illustrative purposes are quoted from the Resolution and Declaration of Trust creating a New York Community Trust:

"(a) For assisting public educational, charitable or benevolent institutions, whether supported wholly or in part by private donations or by public taxation;

"(b) For promoting scientific research for the advancement of human knowledge and the alleviation of human suffering or the suffering of animals;

"(c) For the care of the sick, aged and helpless;

"(d) For the care of needy men, women and children;

"(e) For aiding in the reformation of (1) victims of narcotics, drugs and intoxicating liquors, (2) released inmates of penal and reformatory institutions, and (3) wayward or delinquent persons;

"(f) For the improvement of living and working conditions;

"(g) For providing facilities for public recreation;

"(h) For the encouragement of social and domestic hygiene;

"(i) For the encouragement of sanitation and measures for the prevention of disease;

"(j) For investigating or promoting the investigation of or research into the causes of ignorance, poverty and vice, preventing the operation of such causes, and remedying the conditions resulting therefrom."

The Size of the Galaxy*—II

New Results from a Study of Star Clusters and the Structure of the Universe

By Harlow Shapley, Ph. D., Mount Wilson Observatory

III. ON THE DIMENSIONS AND ARRANGEMENTS OF THE GALACTIC SYSTEM

IN the first article of this series we have discussed the scope and adaptability of those methods of measuring uncommonly great sidereal distances that involve the luminosity of particular types of stars. We have passed from this to a general description of a typical globular cluster for which the distance has been measured by the new methods. Having thus learned something of their great dimensions, something also of their internal organization which appears quite independent of our stellar system or of any other external mass, we are lead to inquire whether these gigantic globular clusters are sidereal "universes" comparable with our own. Our studies show their richness in stars of normal types, their enormous distances from the sun, and their isolation in space. Their flattened form simulates our own galactic concentration of stars; while in frequency of colors and magnitudes, the conditions in distant clusters do not appear to differ greatly from conditions in the solar neighborhood.

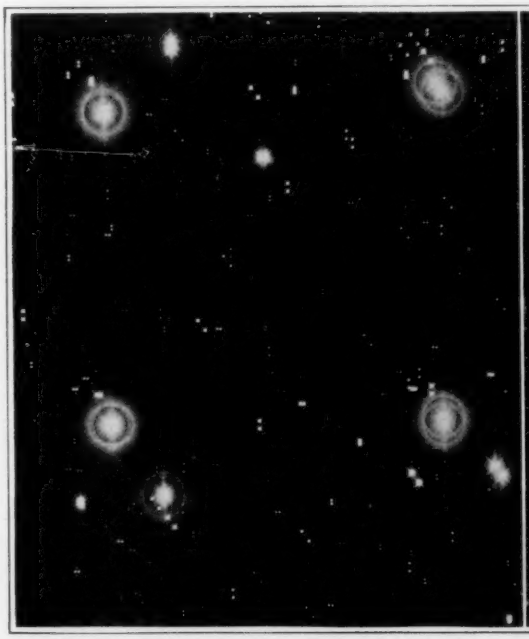
Certain difficulties, however, stand in the way of accepting the hypothesis of close similarity to our stellar system, and these difficulties lead to a closer study of the relation of globular clusters to the general sidereal conglomerate that we call the Galaxy. In the first place, the condensation of stars at the center of a globular cluster is incomparably greater than that around the sun—and the sun has heretofore been thought to be near the center of the known stellar universe. Second, the globular clusters are concentrated to a point in the southern Milky Way, suggesting some sort of relationship to and dependence on the central plane of the galactic system. Third, some investigations of the colors and probable distances of the faint stars of the Milky Way indicate that the dimensions of the galactic system are really much in excess of the usually accepted values, and therefore that the globular clusters are relatively too small to be treated as close analogues.

The inquiry into the possible significance of a globular cluster in the general sidereal scheme has naturally proceeded from the detailed analysis of two or three of the brighter objects to a comprehensive investigation of the distances and distribution in space of all known globular clusters. The completeness of our material is a great advantage in this study: it means that the time is opportune for a consideration of the total assemblage of globular clusters—that conditions now favor a search for signs of organization and relationship among these four score cosmic units.

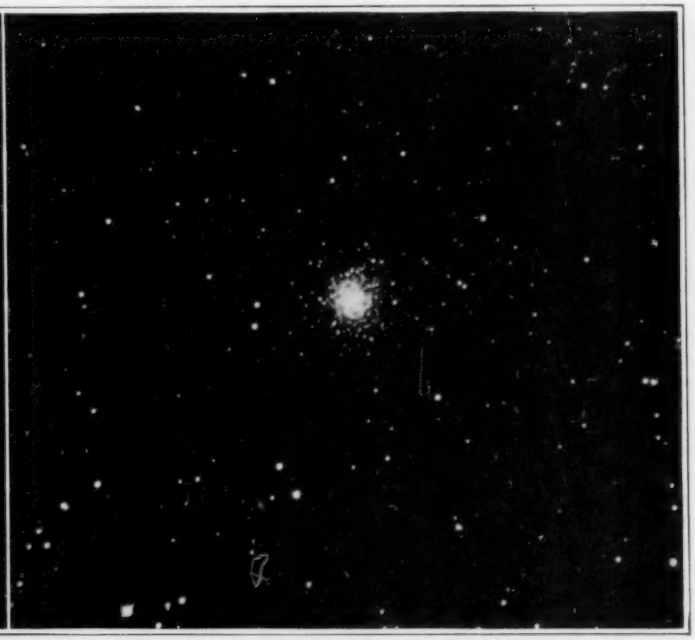
The methods and observational work involved in the determination of the distances need be reviewed but briefly in this place, omitting discussion of the details, which are mainly of technical interest. The presence, in some clusters, of Cepheid variables of known period and brightness permits accurate measurement of distance, thanks to the valuable characteristic behavior of Cepheid stars. Correlation of the brightness of the variables with the brightness of other stars that are always present in globular clusters, extends to clusters without variables; this photometric method of measuring distance and the correlation of these distances with apparent diameter and with total brightness yield simple means of estimating the distances of all globular clusters prior to knowledge of variability or brightness of their individual stars. Much observational work has been necessary to establish definitely whether or not certain faint objects are globular clusters; and for the objects too far south for study at Mount Wilson, photographic records from other sources have been used.

From such analyses we have finally obtained values of the distances of eighty-six objects, all but a few of which are known certainly to be globular. As the coordinates of these clusters on the celestial sphere are accurately known, we

*Adapted by the author from a series of articles published in *Scientia*, October, November, 1919, February, March, 1920.



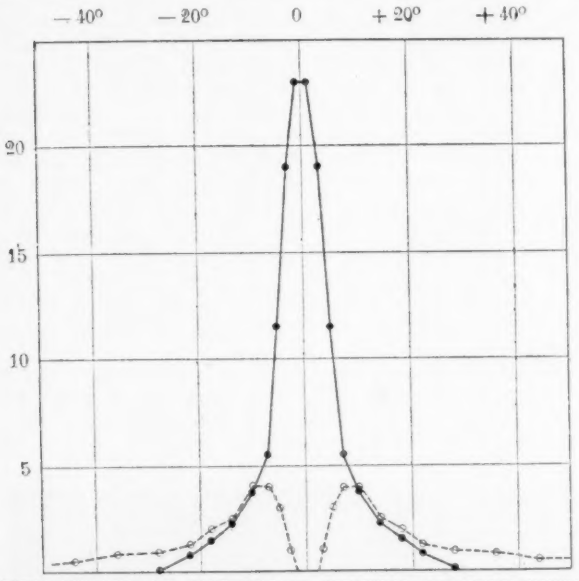
THE PLEIADES—A DETAIL IN PHOTOGRAPHIC PHOTOMETRY OF STARS



THE MOST DISTANT OBJECT NOW SHOWN IN THE UNIVERSE—THE GLOBULAR CLUSTER N.G.C. 7006

easily derive the positions in space of them all, and may plot these positions in three dimensions and study the result.

The Distribution of Clusters.—It has been known for many years that globular clusters are distributed in a peculiar manner. They are almost completely absent from one-half of the sky. North of the celestial equator there are about a dozen, nearly all of them bright and relatively near. South of the equator they are numerous, particularly in constellations along the Galaxy—in Scorpio, Sagittarius, and Centaurus. In that region some are bright, others are very faint and distant. They have an apparent affinity for the Milky Way, becoming more numerous as the galactic circle is approached from either side. It has been generally thought that they are concentrated in the ordinary way to this fundamental plane, presumably with maximum frequency at the center of the Milky Way, as is the case for many types of stars. A closer examination of the distribution, however, shows that these spheroidal systems, in striking contrast to the open clusters, are not most frequent at the galactic circle. Indeed they are completely missing from the middle part of the galactic belt—scarcely one within five degrees of its central line. Their greatest frequency is some seven or eight degrees from the plane



DISTRIBUTION OF SPHEROIDAL SYSTEMS (BROKEN LINE) AND GLOBULAR CLUSTERS (SOLID LINE) NEAR THE GALACTIC CIRCLE

of the Milky Way—a maximum on both sides, but a conspicuous minimum at the galactic circle. There are twice as many open groups, as globular clusters, but they are nearly all within the mid-galactic belt, ten degrees in width, from which globular clusters are absent.

The pronounced increase in the number of globular clusters, as the galactic circle is approached from either side, and the still more remarkable abrupt decrease in the number, just as the densest stellar regions are attained, suggest that here we have a phenomenon of high importance. Notwithstanding their great distances from the sun, and from each other, we must conclude that the plane, with respect to which they are symmetrically arranged, is none other than the plane to which the nearer open clusters congregate, that is, the galactic plane, which is also a fundamental factor in the distribution of stars of all types, of star clouds, and of various kinds of nebulæ.

The System of Globular Clusters.—The nearest globular system, Omega Centauri, is some 20,000 light-years away—a distance that is about fifty times the greatest that has been successfully measured by direct trigonometric methods, a distance several times the radius formerly assigned to the whole galactic system. Some of the other well-known bright clusters have distances in light-years as follows:

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The distances of more than twenty-five globular clusters are in excess of a hundred thousand light-years; some distances approach the double of that value; and one remarkable system in the constellation Delphinus appears to be 220,000 light-years from the sun. This object, N.G.C. 7006, has been specially studied at Mount Wilson, and in the numbers, colors, and absolute luminosities of its stars it appears to be very similar to Messier 13 and Messier 3.

Viewed as a whole, the globular clusters form a great, roughly defined, spheroidal system, symmetrically divided by the plane of the Milky Way. Along the galactic plane the system appears to be at least three hundred thousand light-years in diameter; perpendicular to the plane it is irregularly and indefinitely limited to about half the foregoing value.

Remembering that their equatorial planes evidently are identical, we infer that the galactic system and the assemblage of globular clusters are coextensive, and that the center of the two systems may be the same. As a working hypothesis that appears to conform completely with the observations now existing, we may propose that the globular clusters are a part and show the outline of an immensely greater organization, in whose dynamic structure the plane of the Milky Way is a fundamental circumstance.

Is the Galaxy Composed of Clusters?—In this paper we are chiefly concerned with the light thrown by recent studies of clusters on the arrangement and size of the galactic system; hence we shall only briefly suggest that the new results also afford ground for discussion of the origin and present behavior of the sidereal system. There appears to be good observational evidence, and some dynamical reasons as well, for considering the galactic system as a mixture of star clusters, in all degrees of disorganizations, and for supposing that it may have originated in the combination of clusters. It may have grown, as it appears to be growing now, by the accretion of other stellar systems. It appears to be an example on a cosmic scale of survival of the fittest, that is, survival of the massive and most stable.

Between the open and globular clusters relationships exist other than the complementary distribution. The spectroscope, in the capable hands of V. M. Slipher, has shown that many, perhaps most of the globular clusters are falling with enormous velocities into the galactic region.[1] Hence we may place some confidence in the hypothesis that the globular systems, in some manner as yet undetermined by observation or theory, are ultimately transformed into the open galactic clusters whose massive stars for a long time withstand the tendency to disintegrate. There is also evidence (1) that stars throughout extra-galactic space are commonly organized into these uniform globular units, (2) that the spiral nebulæ represent a different kind of generalized sidereal unit, and (3) that the flattened galactic system as a whole is moving through space.

We see as yet no evidence of external galaxies comparable at all with our own. Possibly they exist; the supposed motion of the galactic system suggests the attraction of an enormous mass; but neither the spiral nebulæ nor the globular clusters appear to attain this grandeur of extent and power. As a single organization, the greater galactic system appears to rule throughout the whole of the sidereal universe that we thus far have explored.

We may summarize by stating that recent study of stellar distances has shown that in volume the galactic system is many thousands of times larger than formerly believed. We have found that at a distance of some sixty thousand light-

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years from the sun, in the direction of the rich star clouds of Sagittarius, lies the center of the galactic organization. The most striking feature of the galactic system, besides its dimensions and probable mass, is the extensive, much flattened, mid-galactic segment, which contains open clusters, isolated stars, and nebulæ in abundance, but is devoid of globular clusters. Whether the absence of recorded globular clusters is due to some dynamical cause or to obscuration by dark nebulosity we do not know. Apparently the globular groups are approaching the segment from without—their radial motions, their distribution in space, and their probable genetic relationships to open clusters support that view. It may be that all the thousands of suborganizations in the galactic system—such as open clusters, star streams, moving groups like those in Ursa Major and Taurus, wide pairs of stars of common motion, long-period visual binaries—originate in these in-falling globular clusters; the galactic system itself, which appears to be little else than a great mixture of disintegrating minor systems, possibly owes its beginning and subsequent growth to globular clusters.

But whatever its origin and destiny, it is clear that the sidereal system is a giant in mass and volume compared with the region around the sun to which we have usually confined our stellar investigations. The interpretations of the greater system, however, will rest largely upon our knowledge of the motions and other characteristics of the nearby stars. It then remains for us to consider from a somewhat novel point of view this local group, which is so important in all our stellar studies.

IV. THE SECONDARY GALAXY AND THE LOCAL STELLAR GROUP

In studies of neighboring stars—those within a region which we may designate as the solar domain—we on the earth have a few distinct disadvantages. In some respects we are too close to our problem. We are too much involved in the minor movements, too much confused, in the bewildering mixture of sidereal bodies, by the unknown or poorly known relations connecting number, distance, spectrum, motion, and brightness. We are confined to a rotating, revolving planet in a moving solar system, which is related in some unknown manner to surrounding stellar organizations, and these also probably rotate and revolve around unknown centers of mass.

Much as the form, extent, and maneuvers of a marching army are better known to the aeronautical observer high above than to the soldier in the ranks, so might our analysis of the solar domain be clarified if we could view it from a distance. The marching soldier would surpass the flying observer in knowledge of the equipment and physical appearance of himself and of a few surrounding soldiers; the terrestrial astronomer would surpass an observer a thousand light-years away in knowledge of our planetary system and of the astrophysical properties of a few neighboring stars. But to decipher the structure and behavior of the army as a whole would be laborious and uncertain for the soldier in the ranks—and the experience of two thousand years has shown how difficult the analogous problem is for the earth-bound scientist.

Our present knowledge of the Hercules cluster, Professor Eddington has remarked, is probably greater, in spite of the enormous distance, than it would be if our solar system were in the cluster's midst. Possibly the greatest advantage of an external position, in the study of the stars of a stellar group, is that all members of a distant compact organization may be considered as equally remote from the observer (the small error committed by this assumption is easily computed), and measures of apparent brightness and motion may be used directly as indicative of actual luminosity and motion.

Let us imagine an observer, situated on a planet physically similar to the earth, at the nearer edge of the Hercules cluster, and let him be equipped with all our modern astrophysical apparatus, with our present scientific knowledge and a capacity for further instruction. From this remote observing station, far outside the star-populated galactic regions, let us, in imagination, view with him the sun and its stellar neighbors. Perhaps from this viewpoint we may gain a clearer idea of the relation of our own local star to the stellar universe, and learn how large a part is played in the galactic scheme by the familiar circumsolar domain.

We call to mind, in the first place, that the observer in the cluster would now be analyzing light of the epoch 34,000 years before Christ, because the light emitted since that time by our own sun and neighboring stars has not yet reached his part of space. That is no serious objection, however, for meanwhile the sidereal system has probably altered in physical aspect only in minor details, such as the comparatively small changes in relative positions and the coming and fading of Novæ. But in another respect our choice of observing station is not happy: our sun would be inconspicuous to a humiliating degree. It would, in truth, be of the twentieth magnitude in visual light, which is less than a tenth as bright as the faintest star that has ever been seen with the greatest telescopes.

To get our sun and similar dwarf stars into his catalogues, we shall bring the hypothetical Herculean observer ten-elevenths of the way from the cluster to the earth. His station is then at a distance of 3300 light-years, and for him Sirius, an eleventh magnitude star, is separated a twelfth of a degree from the sun, a star of visual magnitude 14.8.

For many years we have been aware of the decrease in number of stars per unit of volume with increase of distance from the sun. Naturally this has been taken to indicate that the stellar system is mainly limited to a thousand light-years or so, and that our sun is near the center of the stellar universe. Recent research has verified the thinning out of stars, not only in high galactic latitudes, but also in the direction of the Milky Way. Hence, the Herculean observer from his new observing station does not see a uniformly populous stellar field around the sun; rather, he sees a stellar assemblage that in density of stars diminishes gradually from a fairly rich center, not far from the sun, to a relatively low density at the perimeter, some twenty or thirty degrees away.

He does not, however, see a complete termination of the whole stellar system a few thousand light-years from the sun, if the interpretation of the Galaxy, given in the preceding paper of this series, is even approximately right. The real galactic system, the greater part of which appears to us in projection as the belt of excessively faint Milky Way stars, appears to the Herculean observer as a stellar cloud, completely filling one-half of his sky and constituted of millions of scattered stars and hundreds of open groups, our solar domain being the most conspicuous group because of its nearness to his station.

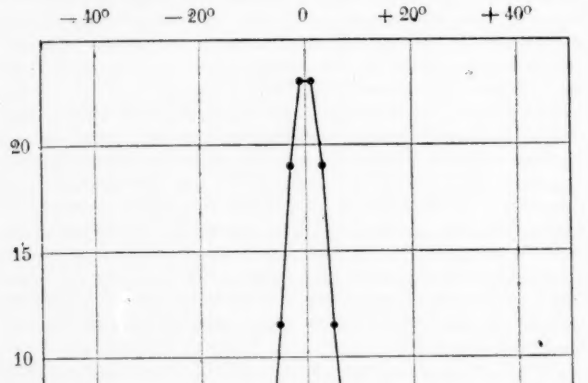
The B-star Cluster.—In an important paper on the structure of the Galaxy, published four years ago, Professor Charlier showed that the bright stars of spectral type B form a flattened cluster, apparently about four thousand light-years in greatest diameter.[1] Since the analysis showed that the size, form, and orientation of this special stellar assemblage agreed well with earlier inferences from other sources relative to the whole of the galactic system, the B-type organization was identified by Charlier with the sidereal universe—that is, the bright B-type stars gave "what might appropriately be called a skeleton image of the Milky Way." More recent research has shown, however, that many B-type stars exist far beyond the limits assigned to this special group, and also that the local group is small in comparison with the galactic system as made known by stellar clusters; but still the evidence of a definitely limited circumsolar cluster of B-type stars remains, and a little consideration shows that it really outlines the same "universe" of stars that previous investigators had inferred from the decreasing stellar density with increasing distance from the sun.

It seemed best, therefore, to re-examine Charlier's material and similar data from the point of view of the larger Galaxy.

[1] *Comptes Rendus, 162*, 872, 1916; Meddelanden fran Lunds Astronomiska Observatorium, Series 2, No. 14, 1916.

easily derive the positions in space of them all, and may plot these positions in three dimensions and study the result.

The Distribution of Clusters.—It has been known for many years that globular clusters are distributed in a peculiar manner. They are almost completely absent from one-half of the sky. North of the celestial equator there are about a dozen, nearly all of them bright and relatively near. South of the equator they are numerous, particularly in constellations along the Galaxy—in Scorpio, Sagittarius, and Centaurus. In that region some are bright, others are very faint and distant. They have an apparent affinity for the Milky Way, becoming more numerous as the galactic circle is approached from either side. It has been generally thought that they are concentrated in the ordinary way to this fundamental plane, presumably with maximum frequency at the center of the Milky Way, as is the case for many types of stars. A closer examination of the distribution, however, shows that these spheroidal systems, in striking contrast to the open clusters, are not most frequent at the galactic circle. Indeed they are completely missing from the middle part of the galactic belt—scarcely one within five degrees of its central line. Their greatest frequency is some seven or eight degrees from the plane



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IV. THE SECONDARY GALAXY AND THE LOCAL STELLAR GROUP

In studies of neighboring stars—those within a region which we may designate as the solar domain—we on the earth have a few distinct disadvantages. In some respects we are too close to our problem. We are too much involved in the minor movements, too much confused, in the bewildering mixture of sidereal bodies, by the unknown or poorly known relations connecting number, distance, spectrum, motion, and brightness. We are confined to a rotating, revolving planet in a moving solar system, which is related in some unknown manner to surrounding stellar organizations, and these also probably rotate and revolve around unknown centers of mass.

Much as the form, extent, and maneuvers of a marching army are better known to the aeronautical observer high above than to the soldier in the ranks, so might our analysis of the solar domain be clarified if we could view it from a distance. The marching soldier would surpass the flying observer in knowledge of the equipment and physical appearance of himself and of a few surrounding soldiers; the terrestrial astronomer would surpass an observer a thousand light-years away in knowledge of our planetary system and of the astrophysical properties of a few neighboring stars. But to decipher the structure and behavior of the army as a whole would be laborious and uncertain for the soldier in the ranks—and the experience of two thousand years has shown how difficult the analogous problem is for the earth-bound scientist.

Our present knowledge of the Hercules cluster, Professor Eddington has remarked, is probably greater, in spite of the enormous distance, than it would be if our solar system were in the cluster's midst. Possibly the greatest advantage of an external position, in the study of the stars of a stellar group, is that all members of a distant compact organization may be considered as equally remote from the observer (the small error committed by this assumption is easily computed), and measures of apparent brightness and motion may be used directly as indicative of actual luminosity and motion.

Let us imagine an observer, situated on a planet physically similar to the earth, at the nearer edge of the Hercules cluster, and let him be equipped with all our modern astrophysical apparatus, with our present scientific knowledge and a capacity for further instruction. From this remote observing station, far outside the star-populated galactic regions, let us, in imagination, view with him the sun and its stellar neighbors. Perhaps from this viewpoint we may gain a clearer idea of the relation of our own local star to the stellar universe, and learn how large a part is played in the galactic scheme by the familiar circumsolar domain.

We call to mind, in the first place, that the observer in the cluster would now be analyzing light of the epoch 34,000 years before Christ, because the light emitted since that time by our own sun and neighboring stars has not yet reached his part of space. That is no serious objection, however, for meanwhile the sidereal system has probably altered in physical aspect only in minor details, such as the comparatively small changes in relative positions and the coming and fading of Novæ. But in another respect our choice of observing station is not happy: our sun would be inconspicuous to a humiliating degree. It would, in truth, be of the twentieth magnitude in visual light, which is less than a tenth as bright as the faintest star that has ever been seen with the greatest telescopes.

To get our sun and similar dwarf stars into his catalogues, we shall bring the hypothetical Herculean observer ten-elevenths of the way from the cluster to the earth. His station is then at a distance of 3300 light-years, and for him Sirius, an eleventh magnitude star, is separated a twelfth of a degree from the sun, a star of visual magnitude 14.8.

For many years we have been aware of the decrease in number of stars per unit of volume with increase of distance from the sun. Naturally this has been taken to indicate that the stellar system is mainly limited to a thousand light-years or so, and that our sun is near the center of the stellar universe. Recent research has verified the thinning out of stars, not only in high galactic latitudes, but also in the direction of the Milky Way. Hence, the Herculean observer from his new observing station does not see a uniformly populous stellar field around the sun; rather, he sees a stellar assemblage that in density of stars diminishes gradually from a fairly rich center, not far from the sun, to a relatively low density at the perimeter, some twenty or thirty degrees away.

He does not, however, see a complete termination of the whole stellar system a few thousand light-years from the sun, if the interpretation of the Galaxy, given in the preceding paper of this series, is even approximately right. The real galactic system, the greater part of which appears to us in projection as the belt of excessively faint Milky Way stars, appears to the Herculean observer as a stellar cloud, completely filling one-half of his sky and constituted of millions of scattered stars and hundreds of open groups, our solar domain being the most conspicuous group because of its nearness to his station.

The B-star Cluster.—In an important paper on the structure of the Galaxy, published four years ago, Professor Charlier showed that the bright stars of spectral type B form a flattened cluster, apparently about four thousand light-years in greatest diameter.[1] Since the analysis showed that the size, form, and orientation of this special stellar assemblage agreed well with earlier inferences from other sources relative to the whole of the galactic system, the B-type organization was identified by Charlier with the sidereal universe—that is, the bright B-type stars gave "what might appropriately be called a skeleton image of the Milky Way." More recent research has shown, however, that many B-type stars exist far beyond the limits assigned to this special group, and also that the local group is small in comparison with the galactic system as made known by stellar clusters; but still the evidence of a definitely limited circumsolar cluster of B-type stars remains, and a little consideration shows that it really outlines the same "universe" of stars that previous investigators had inferred from the decreasing stellar density with increasing distance from the sun.

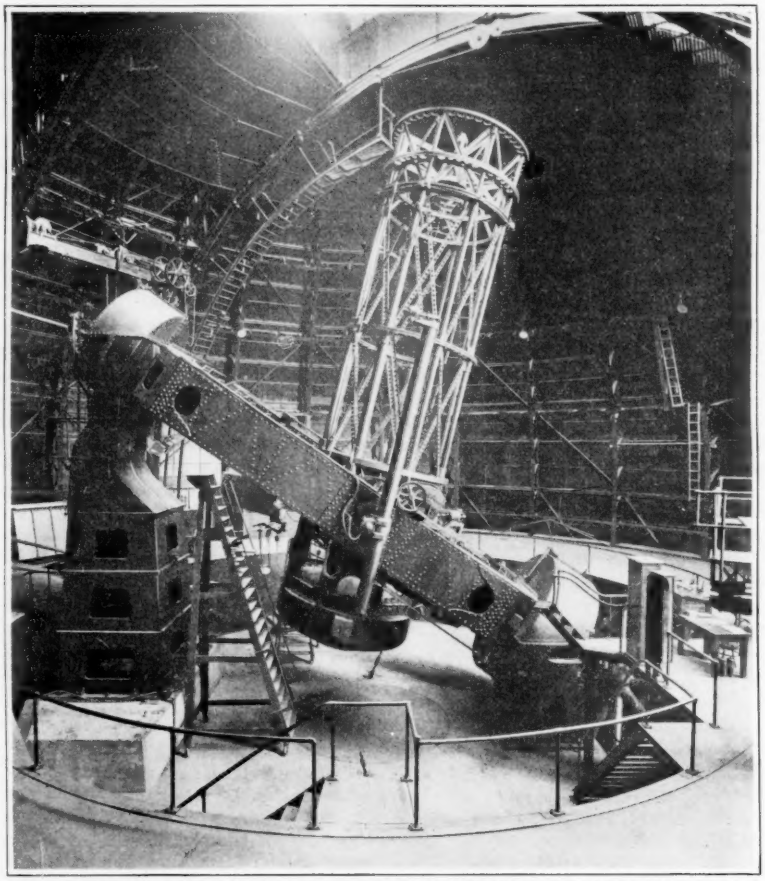
It seemed best, therefore, to re-examine Charlier's material and similar data from the point of view of the larger Galaxy.

[1] *Comptes Rendus, 162*, 872, 1916; Meddelanden fran Lunds Astronomiska Observatorium, Series 2, No. 14, 1916.

We shall not discuss here the methods, details, and lesser results of a rather extensive investigation. The principal results include the demonstration that the central planes of the system of bright B-type stars and of the galactic system do not coincide, and this lack of coincidence becomes at once the strongest proof of the actuality of a distinct local organization. The open clusters, the globular clusters, the galactic Novæ, the Cepheid variables, the star clouds—classes of objects extending far beyond the bounds of the solar domain—all define one and the same plane; they all appear symmetrically distributed with respect to the generally accepted galactic circle. But we now find that the brighter stars of spectral types B and A (and we infer that the same holds for all stars of the local cluster) are symmetrically organized about a plane that is inclined between ten and fifteen degrees to the galactic circle.

The small inclination has undoubtedly helped to conceal the existence of the local group, much the same as the position of the sun not far from the center has led us to limit erroneously the whole galactic system by interpreting as a universal rather than a local phenomenon the decrease in star density with distance.

From several lines of evidence we find that just beyond the limit of the local cluster there is also an abundance of stars — members of the general galactic fields; and from this fact, and from various observational results concerning the nearer stars, we infer that galactic stars and cluster stars are thoroughly intermingled throughout the whole extent of the local group, the field stars becoming proportionately more numerous with increasing distance from its center. It appears probable that some of the smaller moving groups, *e.g.*, the Ursa Major system, are interpenetrating clusters of the field, independent of the much larger local system and in structure and motion essentially undisturbed by it.



INTERIOR OF THE DOME, MOUNT WILSON OBSERVATORY, SHOWING THE 100-INCH TELESCOPE

Some stellar types are much more frequent in the cluster than in the field, and a study of their distribution and motions gives us results directly applicable to the cluster alone. Other types such as the Cepheid variables and the planetary nebulæ appear to be almost exclusively members of the field, and they are of service in orienting the cluster and in studying its motion as a whole. But most of the normal types of stars are probably common to both field and cluster, and the study of either the cluster or the field on the basis of our knowledge of such stars will be attended with obvious difficulties and uncertainty. To the observer at the station one-eleventh the way to the Hercules cluster, however, the analysis of content and extent would present no serious obstacle.

We must regard as preliminary many of the results so far obtained relative to the local cluster, but a few points not mentioned above seem definite enough to be enumerated with brief discussion.

(a) B-type stars are near the plane of the secondary Galaxy even at a distance of some 1200 light-years from the sun, but are quite absent in high galactic latitudes. The local cluster accordingly appears to be very flat so far as blue stars are concerned, and is probably much larger than the typical open clusters of the galactic segment. In dimensions it possibly approaches the Magellanic Clouds or some of the more sharply defined of the star clouds of the Milky Way.

(b) The center of the local cluster is between two and three hundred light-years from the sun (in the direction of the constellation Carina), according to Charlier's determination. My later investigation suggests that his value of the distance may be at least a hundred light-years too large.

(c) It is not clear now, and may never be certainly known, whether our sun is a field star or a member of the local cluster which includes a majority of our brightest naked eye stars. The sun may have originated when and where the other stars of the cluster began their careers. On the other hand, as a field star, it may have no relation to the cluster. In that case it would be only a matter of fortune that during man's term of existence on the earth his night skies have been brightly illuminated by a great group of drifting stars unrelated to our own luminary.

A Secondary Milky Way.—As stated above, the local cluster is a very oblate spheroid, and some classes of stars appear to be strongly concentrated to its equatorial region. Perhaps the most remarkable effect of our position not far from its central plane is that the position of the cluster stars on the surface of the sky gives rise to what we may call the secondary Milky Way. The primary Galaxy chiefly owes its appearance to the projection on the surface of the sky of the thousands of millions of stars that exist in the galactic segment. The secondary Galaxy owes its lesser but distinctly perceptible tracing across the sky to the considerable extent of the local cluster along its own central plane and to the resulting apparent concentration of a majority of its stars to a narrow belt.

Though the secondary Galaxy is well defined by star analyses throughout its complete circuit of the sky, to the naked eye it is most clearly seen where it stands out some ten to twenty

degrees along the west side of the Milky Way—from Perseus southward through Taurus, Orion, and Canis Major to Puppis and Carina. Not only the very bright stars of types B and A throughout this region are to be assigned to the cluster, but also the rich belt of stars with magnitudes from three to seven. On the other side of the Milky Way from Orion and Canis Major, at the same distance from the galactic circle, we find in Cancer and Hydra no counter-part of this richness of naked eye stars; and the interjacent constellation Monoceros is almost destitute of stars brighter than the sixth magnitude, though it lies along the central line of the Milky Way, and is surpassingly rich in telescopic stars of the far-extending galactic segment. It is this distribution of bright stars, now attributed to the orientation of the local cluster, that long ago led Sir John Herschel, and later B. A. Gould, to point out that the most luminous stars of the sky define a belt that is not coincident with the Milky Way.

If we could look at the local cluster from the hypothetical external position, might it not be possible to solve some problems of the remarkable community motions of the brighter stars—Kapteyn's two star streams and similar systematic drifts? Possibly we have made a real advance toward the solution through our imaginative view from without, that is, through the conception of the solar domain as a suborganization situated in the heterogeneous fields of stars and clusters of the galactic segment. The flattened form of the local cluster suggests an internal motion of its members analogous to rotation; and the chance that the cluster also moves as a whole is enormously greater than the chance that it is completely at rest with respect to the surrounding and intermingling galactic field. When the local cluster moves the inevitable result is star-streaming—a preferential drift in the direction of the cluster's motion for cluster stars, and in the opposite direction for stars of the field. Superposed upon this true stream motion there should be a pseudo-stream motion, due to the rotational or oscillatory movement of the individual stars with respect to the cluster's center of mass.

Much evidence relating to the preferential motion of the stars appears to be in full agreement with this hypothesis of star-streaming, but as yet we cannot definitely say what part of the observed systematic drifts should be attributed to the motion imposed on the cluster by the galactic system, and what part should be attributed to the internal individualistic behavior of the cluster's stars.

FERROCERIUM AND THE OTHER PYROPHORIC ALLOYS

IT was in 1903 that Welsbach discovered that certain rare earth alloys, when rubbed with a file, emitted brilliant sparks, which were able to ignite combustible gases. A few years later it was found that the best results could be obtained by the admixture of 65 parts per 100 of iron. These alloys have an action, similar to that of flint and steel, but the spark can be produced more easily than with the ordinary tinder box of gone-by days.

The mixture of rare earths consists principally of cerium, lanthanum, didymium, neodymium, praseodymium and samarium. All these metals are white in sunlight; their ordinary color is yellow and they oxidize with difficulty in air.

The mixture, which the Germans call "misch metal," possesses properties which vary according to the way in which the product is manufactured. One alloy, coming from a large chemical factory, is very malleable, while another, made by a plant working with an electric reduction method, is very hard and very brittle. The fragility is attributed to the presence of silicon among the impurities.

While the original pyrophoric alloys, made by Welsbach, contained about 40 parts per 100 of iron, the present day products contain only 15 per cent iron, but about 2 per cent bismuth or antimony are added in order to make the alloy hard. Silicon is found in all the ferrocerium alloys, partly because it is present in the original crude metal and partly because the crucibles used in the manufacture are made from clay. About 5 per cent of copper is added by certain plants in order to produce a pyrophoric alloy with not too high a melting point.

The pyrophoric property of these alloys is explained according to various theories. Some authorities say that this peculiar property is due to the presence of nitrides in the ferrocerium; others say that hyrides or suboxides are responsible for this action. No theory, however, has been confirmed by actual experience.

Certain of these alloys, made with mercury or platinum, which, however, possess no industrial interest, because of their price have been found to be very explosive. A platinum alloy, containing 25 per cent of the metal, has some of the well-known properties of the ordinary ferrocerium. The alloys made from zinc and cerium are particularly interesting because of their use in the illumination of the lamps used in mines. Those containing borium and cerium are also very useful for this purpose. A very fragile and easily pulverized alloy is obtained by the addition of 25 per cent of aluminum or magnesium to the ferroceriums.

The lower grade pyrophoric alloys which contain a high percentage of carbides are very unstable. They must be protected from the air by a coating of oil; otherwise they will be oxidized very readily and speedily become totally useless.

The raw materials that are used in the manufacture of the ferrocerium alloys are obtained generally from the residues recovered in the process of making incandescent mantles from monazite sand. After the thorium has been extracted from these sands, there remains a residue of the oxides of the rare earths, which is known by the name of "misch." The majority of the plants making these alloys produce ferrocerium by the electrolysis of the anhydrous chlorides of cerium, lanthanum, didymium, etc. An attempt has been made to use the fluorides of the metals of the cerium group, but poor results have been obtained thereby. Instead of a solid mass of the "misch" metal as is obtained with the chlorides, a thick pasty product is procured which cannot be used.

The electrical process of manufacturing ferrocerium requires cheap current. The crucibles are generally made from graphite or clay and are provided with large iron cathodes. Sometimes iron crucibles are used which have double walls so that they can be cooled by means of a current of water.

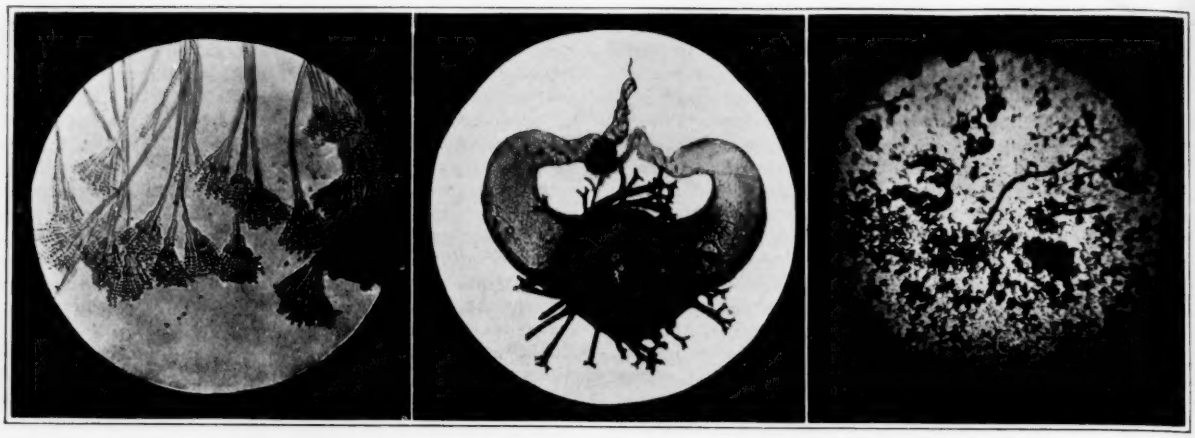
In the early days of this industry, the small pyrophoric stones that were sold were just little fragments of metal weighing only a quarter to a fifth of a gram. They were more or less scientific curiosities. At the present time there are to be had different types of tinder boxes on the market.

In one of these the pyrophoric alloy is made in the form of a small stick against which a small wheel made of hard steel rubs, the surface of which is striated just like a file. When the wheel turns, a shower of sparks is formed, which are directed against a cotton wick soaked in gasolene or benzine, causing it to ignite. Another type of tinder box has a long rod of the pyrophoric alloy which is scratched by a sharp point of hard steel. The sparks impinge on a thread of asbestos, soaked in gasolene. When the point is not in use, it is lodged in a small chamber in the apparatus.

The great market for the ferrocerium alloys in the United States is for the manufacture of the automatic gas lighters, while in Europe where the match industry is a state monopoly, its principal consumption is in the manufacture of tinder boxes. —*Rev. Chim. Ind.*, 1921, 88-89.

THE HANDLEY PAGE SLOTTED AEROFOIL

A PAPER read before the Roy. Aeronaut. Soc., Feb. 17, 1921, describes the results of experiments on slotted aerofoils of various designs. The increase in lift coefficient possible with the slotted aerofoil permits either of slower running speeds than at present or, alternatively, of less power at top speed. At top speed it is possible to work at lift coefficients of between 0.2 and 0.3.



A TYPICAL COLLECTION OF PATHOGENIC BACTERIA FOUND ON FRENCH PAPER MONEY

Dirty Money and Disease

Happy Homes for Dangerous Germs in Worn-Out Banknotes and Coins

By Jacques Boyer

EVER since the teachings of the great Pasteur gave an entirely new slant to our ideas of disease thoughtful persons have been disturbed by the evident danger of the propagation of infectious maladies by means of objects which pass from hand to hand among the general public. There are numerous facts which prove that the germs of certain maladies are transmitted, for example, by means of books, bank notes, and gold, silver, nickel and copper coins. How many volumes, for instance, might not be contaminated by a tuberculous patient, constantly coughing, sneezing and spitting during the last months of his life? What huge numbers of microbes, of Phycomycetes, of microscopic algæ, and of the spores of the Mucorhinea or molds, paper money and small coins are liable to accumulate in the course of their travels from pocket to pocket among peasants, laborers, and even among citizens of the better sort! The fears of the hygienists are only too well founded at the present time, in view of the repulsive dirtiness of the small bills found nowadays in general circulation.

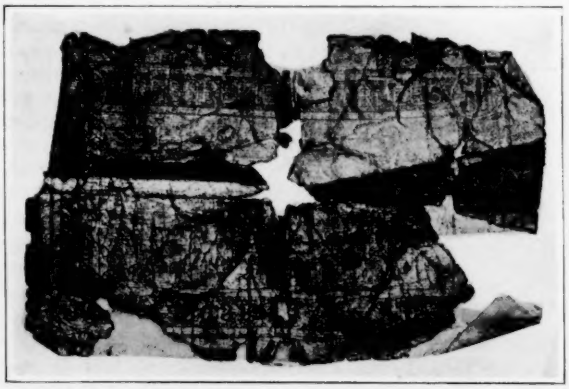
The microscope reveals to our startled eyes a frightful number of bacteria and of molds within the folds of the *filthy rags* which we are often forced to use as money, some of which, moreover, often have their pieces pasted together with strips of gummed paper. Moreover, these small bills rapidly deteriorate from the very fact of their intensive circulation. Like the Wandering Jew, paper notes of low denominations never rest upon their travels, whereas their rich cousins, the big bank notes, enjoy a period of repose from time to time within the bill-folds of the well-to-do, or the strong boxes of financial establishments.

While we wait as patiently as we may to have these disgusting bits of paper replaced by handsome coins . . . let us make a closer study of these invading micro-organisms and of the means employed to destroy them.

More than 30 years ago the Hungarian botanist, Jules Schaarschmitt, detected the presence of abundant cryptogamic vegetation (Schizomycetes, Saccharomycetes (yeasts) Algæ, etc.) as well as of a number of microbes, mingled with the débris of starch, of linen or cotton fibers, of fragments of hair and other organic matter, upon paper money. At about the same time Prof. Rainsch d'Erlangen likewise discovered the presence of various algæ and bacteria upon copper, silver and gold coins issued by various European governments.

We, ourselves, have likewise examined a certain number of small French notes of a much worn character, and can, therefore, give our readers direct evidence as to their condition. Furthermore, any one who reads these lines may verify most of our experiments, provided he happens to possess a microscope having a magnifying power of from 250 to 300 diameters.

Take a needle or scalpel and slightly scratch one of the dirty spots upon a worn bank note, then place the fragments thus obtained in a drop of pure water resting upon the object glass of a comparatively powerful microscope. Within the material taken from bank notes, even those which are least soiled, the observer will find a number of varieties of Saccharomycetes (including brewers' yeast and various other yeasts), great numbers of microscopic algæ and bacteria(micrococcus), various bacillæ, especially the *bacterium terma*, which is the agent of putrefaction and the *Leptothrix buccalis*, a parasite which is particularly abundant upon the tongue, in the saliva, and within the interstices of the teeth. More rarely we have observed the sporanges of the *Mucor mucedo*, some of the lower fungi, such as the *Phycomycetes nitens* and even minute nematode worms, such as the small vinegar mite, as well as such organic débris as fibers of cloth, grains of starch, and bits of hair, fur, etc. Photomicrographic views of these pathological germs and these heterogeneous mixtures offer many surprises to persons who have been harboring them in their habitations.



A FRENCH BILL ACTUALLY FOUND IN CIRCULATION BY THE INVESTIGATOR OF DIRTY MONEY

The differences in the bacteria found on bank notes and on coins are not so great as might be supposed. All of the microscopic algæ, in fact, pullulate much more freely upon the

CONTRARY TO GENERAL IMPRESSION, COINS MAY BE NO LESS FILTHY THAN BILLS

REMOVING THE BACTERIAL INCRUSTATIONS FROM COINS FOR MICROSCOPIC EXAMINATION

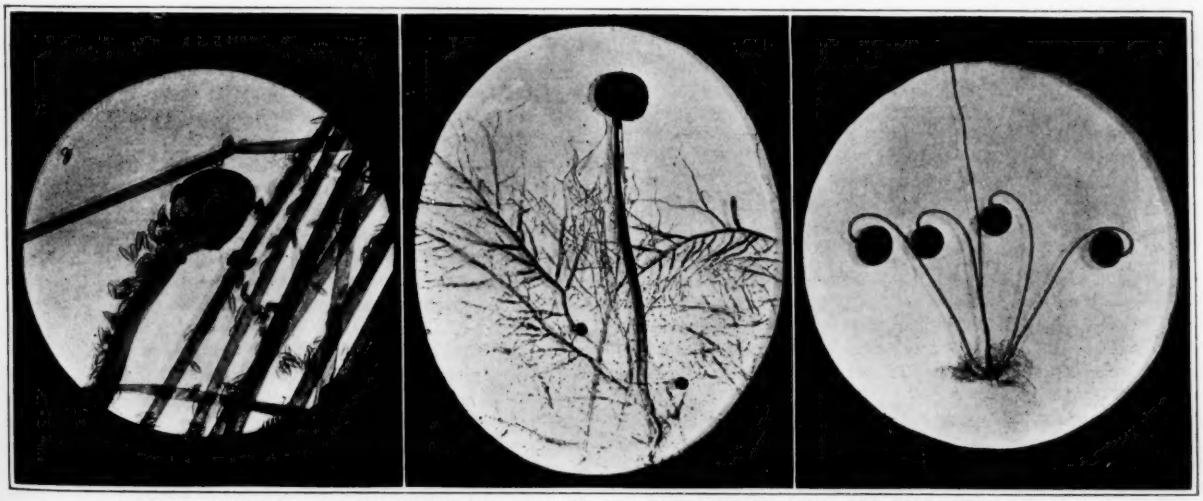
latter than upon the former; on the other hand, there are many more colonies of microbes to be found upon the grease spots and within the black and tortuous folds of the paper money.

Samples taken from the surface of metal coins are examined in the same manner as those taken from paper money. The incrustations of dirt in the crevices of the coins are scratched and the particles obtained put in a drop of distilled water and placed upon the object glass of a microscope.

Dr. William H. Parker of the United States has recently made a number of interesting studies along this line. He began by sowing bank notes and coins with the bacilli of diphtheria; upon later examination he found that these germs retained their virulence for several weeks. He then subjected to microscopic analysis the daily money receipts of various business houses. In this manner he discovered no less than 26 diphtheria baccili colonized on copper pennies; forty upon silver half dollars; 1,250 on comparatively clean bank notes and colonies containing as many as 75,000 living on dirty bills. Dr. Thomas Darlington, Director of the Bureau of Health in New York, has made the proposition that "greenbacks" should be withdrawn from circulation, because of the deplorable habit of most persons of handling and folding them so that they can be slipped readily into their pockets. After a few months of such usage these rolls of American paper money are scarcely safer to handle than our infected small French notes!

An American technologist named F. B. Churchill has invented a means of "rejuvenating" $5, $10 and $20 bank notes no less than three times before it becomes necessary to destroy them. This method consists in washing and drying the notes in the following manner: They are first placed in a hollow ball having its surface pierced with a number of holes; the ball is then put into a boiler within which a very hot soap and water solution is circulating with great rapidity. After this preliminary cleansing the ball (this huge spherical colander) is removed to a vat full of a "solution" of starch, and then into a third container where the contents are dried by a current of air. Finally, the notes, which are now both clean and dry, are "ironed" by being passed through hot metal rollers.

Still more recently an improved machine has been invented by Mr. I. Ralph, the Director of the United States Treasury at Washington, which is capable of washing and disinfecting dirty bank notes at one and the same time. The soiled notes



ANOTHER EXHIBIT OF THE DANGERS TO WHICH THE HANDLING OF COINS AND BILLS EXPOSES ONE

are placed between two endless bands of cloth and are thus carried first through the wash-water and then through the rinse-water. They are then submitted to gentle friction or rubbing while at the same time the cleansing process is continued by the alternate saturation with a disinfectant and "squeezing dry" of the endless bands of cloth. Before leaving the apparatus they are passed into a second pair of cloth bands which run through large iron rollers heated by gas; these rollers dry them and smooth them in a single operation. With this machine a couple of women can wash 4,000 bills per hour, not only destroying all microbes, but disinfecting them so as to make them sanitary and fit to be delivered once more to the public.

When bank notes are too much worn, too dirty, or too badly mutilated to be fit for public circulation they are destroyed either by chemical processes or by fire. In the United States bundles of condemned bank notes are thrown into huge cutting machines whose immense blades quickly reduce them to fragments. The latter are then macerated in a solution of caustic soda or potash till they have been transformed to a pulpy liquid. In France, however, this mode of treatment was long ago abandoned and the notes are incinerated instead.

The apparatus used for this purpose in the National Bank of France is heated by a gas furnace. It is composed of a simple metal retort having a false bottom, and provided with openings at the top and bottom which can be closed by tampons; it is almost entirely surrounded by a jacket of fire-brick. Thanks to certain clever devices connected with the apparatus the heating of this ingenious crematory furnace is very largely accomplished by the distillation products which proceed from it. For this reason 50 fr. worth of gas is sufficient to reduce to ashes 15 million hundred franc notes!

It is certainly greatly to be hoped that the various Chambers of Commerce in authority will give the order that the bills and notes issued during the war which are now in such a lamentable state be withdrawn from circulation and committed to the flames. It is to be hoped too that these filthy rags which are such dangerous agents of infection will be replaced as soon as possible by 1 fr. and 2 fr. coins of aluminum bronze. It may be remarked here that *Schizomycetes* is the term preferred by botanists to designate the minute vegetable organisms more popularly known by the name of bacteria. They consist of single cells, which may be round, oblong or rod-like in shape, or of aggregates of cells. They lack the chlorophyll or green coloring matter possessed by plants higher in the scale. They multiply with enormous rapidity by the process of cell-division. It is because of the absence of chlorophyll, that marvelous chemical substances which enables plants with green leaves to elaborate organic from inorganic substances, that nearly all bacteria are either parasites or saprophytes, *i.e.*, they prey upon either living matter or dead.

The usual size of bacteria is 1 micro-millimeter in diameter and from 2 to 5 times as long, though both smaller ones and larger ones are known. Some bacteria produce spores—these are minute reproductive bodies which represent a resting stage of the organism. When "ripe" these spores are spherical, ovoid, or long-ovoid in shape. They are extremely small—*e.g.*, those of the *Bacillus subtilis* measure only 0.0012 mm. in length by 0.0006 mm. in breadth. Spores are doubly dangerous as agents of disease, first because of their minute size, which enables a single dirty bill to harbor many thousands, and secondly, because they are extremely resistant to destructive agents such as heat, cold, dryness, etc. They are capable on the one hand of germinating immediately under the proper conditions of food and moisture, and on the other of retaining their vitality for months or even years.

In closing this brief article the writer wishes to lay especial emphasis upon the truly filthy and disgusting practice to which many persons are addicted of facilitating the counting rolls of bills by moistening the finger in the mouth—thus affording any pathogenic germs an immediate entry into the body. Other careless persons run a risk of deadly infection by holding a bill between the lips when making change, and still others by handling dirty money and their bread or fruit without first washing the hands.

Migratory Cells*

Recent Studies of the Part Played by Cells that Wander from One Tissue to Another

By Jean Dufrenoy

RECENT researches in zoology and botany have given us fresh information and new examples of migratory cells, which are capable of changing their position in the inert milieu between the cells of the tissue or even of penetrating other cells.

The former, which are true migratory cells, change the position of their complete cellular bodies from one region of the organism to which they belong to another, or even quit the original organism in order to emigrate into some new host.

Other cells remain immovable, as respects their original structure, but they prolong themselves in such a manner as to extend into the tissues which surround them.

I. INTER-CELLULAR MIGRATORY CELLS

Among molluscs there may be observed a transition from total migration to localized migration—in other words certain outer or ectodermic cells migrate entirely toward the mesodermis losing all connection with the ectodermis which produced them, while others merely extend their sole proximal extremity, prolonging it into the mesodermis, while their distal portion remains in its original position in the ectodermis.

a.—HYPHAL CELLS

The processes or prolongations of a cell extending into neighboring tissues are sometimes excessively elongated, forming in the Laminaria (certain seaweeds) what Sauvageau has termed "solenocysts" and "cylindrocysts" and in certain of the Phanerogams or flower-bearing plants laticiferous or latex-containing cells, latex being the milky fluid found in many plants, one of the best known examples being rubber.

These hyphal cells travel between their kindred cells by digesting the pectic lamella which cements the membranes, behaving exactly like those endothophic or internal parasites which occasion no reaction on the part of the organism which acts as their host.

b.—THE TRUE MIGRATORY CELLS

The mesenchyma produces cells which wander from one tissue to another either perpetually or temporarily. (For the benefit of the lay reader it may be remarked that the mesenchyma is the term given in embryology to the network of branching cells from which are produced the connective tissue, the blood, the lymphatics, etc., etc.).

*Translated for the *Scientific American Monthly* from the *Revue Générale des Sciences* (Paris) for November 30, 1920. The original article contains no less than fifty notes referring to the various authorities consulted in its preparation. Because of our limited space we are obliged to omit these except for a few which we have incorporated in the text.

The former of these, which are known as amoebocytes and which have been the object of much research, may be produced in great numbers by the mesodermis in general or by certain of its differentiated areas. Their production is regulated by the conditions of metabolism in the organism at any given time; thus it is greatly increased, even to an exaggerated degree by certain infections, whether these be accidental or experimental (Vide Chapter 3).

Their migratory activity is variable and depends upon what is known as "functional gymnastics"; this activity can be much augmented by vaccination.

The various tissues are more or less easily penetrated by the migratory cells or amoebocytes—some tissues allow these cells to circulate freely in their midst, others derive food from them or imprison them, as in the case of the plasmatocysts.

The degree of penetrability to amoebocytes also varies with the physiological condition; *e.g.*, the gangrene of Wrisberk becomes infiltrated with lymphocytes in subjects suffering from syphilis.

In the course of ontogeny (*i.e.*, the development of the individual) while the organs are being formed by the grouping together of typical migratory cells, there sometimes occurs a rearrangement in the distribution of the cellular materials which may profoundly modify the original organic relations. Thus there may be *an inversion of the lamellæ* or *the body may be rendered dissymmetrical.*

1. *The Inversion of the Lamellæ.*—Among various larvæ as well as among many seedlings the superficial cells may become buried in the interior of the body.

Thus, the ectodermic and endodermic lobes are inverted in the sponges, when all of the ciliated superficial cells are buried in the interior of the larva to form the endodermis.

This inversion takes place at an earlier stage in the *Microcyema vespa* in which the fifth uneven cell—the most external cell of the embryo—insinuates itself among the four other cells and becomes completely internal.

Instead of being complete, however, this inversion may be *reduced to a mere tendency*—thus certain ectodermic cells bury themselves in the mesodermis in order to form the spicules of the stony framework or skeleton of the coral, or to form the oenocytes of the adipose masses of the ant.

It is by means of an inversion, also, that the so-called "muticlavre cells" are formed in the laminaria (*Sacchorhiza bulbosa*); these quit the cortical ectodermis and become buried in the interior of the thallus where they unite with the original elements of the pith leaving the other cells the function of filling the hollow spaces.

2. *The Cellular Rotations.*—It is possible in some cases for the larval development to cause an alteration in the organic relations, whereupon certain cells may undergo a change of position. Lameere has explained the dissymmetry found in the nematogen (the vermiform embryo) of the Dicyemids as being due to a rotation through 90 degrees of the internal mass, thus setting in a row three couples of internal cells originally having a transverse arrangement.

However, examples of torsion due to an *active movement* of cells are quite rare, since the "rotation" of cellular masses may be *merely a relative phenomenon*, as shown by Van Wijhe in his explanation of the asymmetry of the larva of the *Amphioxus lanceolatus*. Thus, the researches made by Boutan, supported by an analysis of the observations of previous investigators, enabled him to explain as being *due to a simple inequality of growth* all the successive causes of the dissymmetry found in the gastropods—*i.e.*, the rotation of the anal region and of the spiral twist of the shell around the longitudinal axis of the embryo (a rotation limited to the region of the abdominal organs in most of the opistobranches—a division of the gastropods), but extending to the average visceral area in the prosobranches (*i.e.*, having the gill anterior to the heart), the torsion upon itself of the œsophagus and of the nervous system; the secondary involution of the shell; and even the possible phenomena of external regularization; or, finally, the displacement of the definite marks of the shell in certain of the lamellibranches (triacne, etc.).

c.—THE ROLL OF THE AMOEBOCYTES

Amoeboism represents the simplest method of the capture of food—a mode which is unique in the amoeba or in the metazoan animal (the metazoa include all animals higher in the scale than protozoa) having no digestive gland, a temporary method in many ovules (*hydra*, etc.), and an accessory method in all of the metazoa which possess phagocytes; the bedbugs even specialize in their amoebocytes, employing them for the purpose of digesting the excess sperm not utilized in fecundation.

It is the office of the amoebocytes to carry nutritious or residuary substances and distribute them and to gather them and eliminate them. Thus it is their function to carry to the new points of calcification in the *Pluteus* (a free-swimming larva) the lime borrowed from the original spicules and to construct the spicules found in the sponges, the corals, the tubitores, and the alcyonaria.

The Bryozoa (or moss animals), the Echinoderms (starfishes, holothurians, etc.), and the Oligochaeta (including earth worms and fresh water worms), actually possess collections of excretory amoebcytes which may be considered to amount in practise to a dissociated organ of excretion, as pointed out by Durham in 1891, in his article entitled *Wandering Cells in Echinoderms* in the quarterly journal of the Microscopical Society.

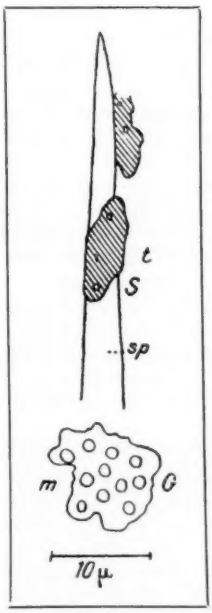


FIG. 1

Actinoblasts of a calcareous sponge which has been for some time in a solution of toluidine blue. *t*, diffused color; *sp*, calcareous spicule; G, granulated amoebocytes, showing inclusions

Affinity Between Amoebocytes and Chemical Salts. — Amoebocytes undoubtedly owe their specific properties to their affinity for various salts. In the transparent animals (*Salpa*, *Hyperia*, big head fish, etc.), when they are examined in a living condition after being placed in solutions of aniline colors we may observe amoebocytes choosing their colors, so to speak, *i.e.*, becoming electively tinged in the midst of organs which remain uncolored. Again, in the case of sponges (*Leucosolenia*), etc., which have lived in solutions of methyl blue or toluidine blues, the actinoblasts (Fig. 1) and the Granular amoebocytes (Figs. 2 and 3) exhibit colored inclusions. Finally, the rapid coloration of the "figured elements" of the blood in animals which have undergone injection is a well-known fact.

d.— THE DESTINY OF MIGRATORY CELLS

Large numbers of aboebocytes are arrested in the conjunction tissue which they serve to enrich, being found especially in the zones which are differentiated in the lymphoid organs—in the thymus there may be observed an epithelial framework enriched with mesodermic amoebocytes.

Sometimes the migratory cells acquire a very high degree of specialization; for example, among the *Cnidaria* (thread cells or stringing cells) many migratory cells during their long travels from their point of origin become differentiated into Nematocysts. Still other amoebocytes group themselves so as to form frameworks of autonomous organs, especially of sex organs: the future germinative cells, which are originally free and migratory in the sponges, the Coelenterates, the Ascidians, etc., and the vertebrates betake themselves to their definite location both by means of their own migration as well

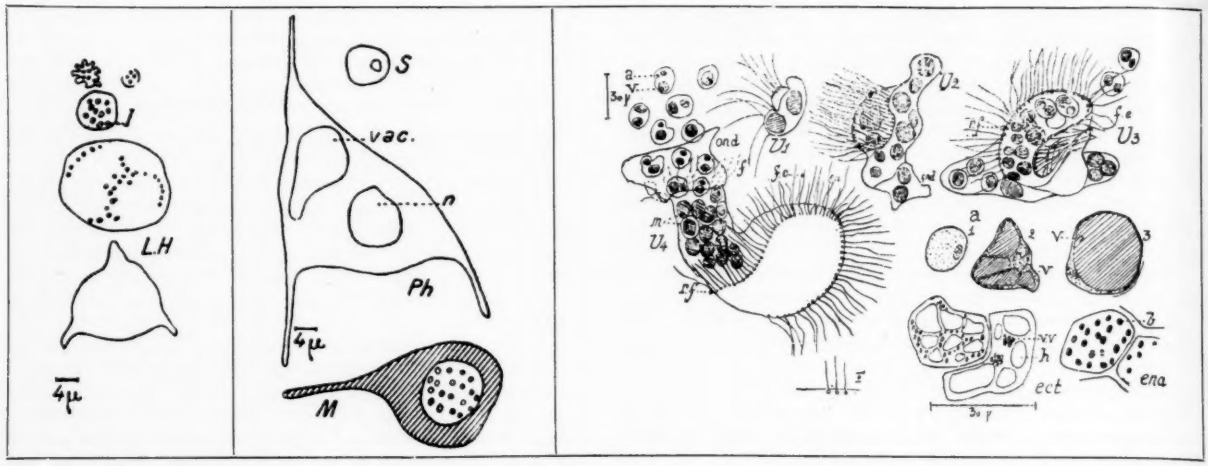


FIG. 2 FIG. 3 FIG. 4

Fig. 2: Living amoebocytes observed in a living hyperia after having been immersed for fifteen minutes in a solution of toluidine blue. *l*: cyanophile inclusions. Fig. 3: Ph., Phagocyte of the larva of the stemographic bostricha ready to enter the nymph stage. M. Basophilous ctyoplasm. *vac*, vacule. *n*, nucleus. *s*, young cell with sperms. Fig. 4: Agglutination of the amoebocytes in a living Molgula ampuloides colored by toluidine blue. *a*, amoebocytes; *v*, violet-colored vacuoles; U_1, U_2, U_3, U_4, ciliated urns of the coeloma, agglomerating the worn-out amoebocytes

as through local inequalities in the growth of the embryo.

When the sex cells have ceased to be amoeboid in character they are capable of annexing to themselves the amoebocytes which transport them, protect them and nourish them, either as they are or by constructing organs specially adapted for that purpose. The most beautiful example of this process is found in the Medusa; this creature has its origin in the Gymnoblastid Hydras (*Cordylophora*, *Pruvotella*, etc.) in a medusary nodule formed by the grouping around the genital masses of amoebocytes which have emigrated from the ectodome of the gonophore.

Whether it be determined by the sex cells or by endo-parasites this attraction appears to be specific in character: parasites such as the Urostora, the worms and the Entomophages are not surrounded unless they are either dead, encysted, or have been introduced into the bodily economy in the form of eggs.

In the mussel those cells which surround the diatoms in a pearl are not migratory but proceed from an invagination of the ectoderm of the mantle, as described by L. Boutan, in his article entitled "The Real Origin of Fine Pearls" (*Arch. Zool. Exp.*, p. 75, 1904).

However, an accumulation of amoebocytes at any infected point of the organism *may be occasioned* by endotrophic bacteria or fungi.

SUMMARY

To sum the matter up, many migratory cells appear to be destined to undergo a speedy death by degeneration of a fatty, a pigmentary, or a sclerous nature. Becoming choked with waste products they become agglutinated as shown in Fig. 4, and either accumulate at certain points in the organism or else are eliminated from the latter. The pigmentary cells accumulate in the liver (*Ichtyopsides*) and the skin, while the scleroblasts accumulate in the skeleton.

There are some other amoebocytes remaining indefinitely youthful and which are even capable of *avoiding death by means of intra-cellular migrations*: thus the migratory gonocytes of the Dicyemids are preserved by the ectodermic cells which harbor them, while the sex cells deintoxicate themselves by conjugation. But this quasi-immortality which the indefinite repetition of the process of sex union confers upon germinative cells, may become absolute in those cells which become cancerous, while, at the same time, they acquire the power of migration.

II. THE INTRA-CELLULAR MIGRATORY CELLS

Among its other properties the migratory cell retains that power of the phagocyte which enables it not only to change its position in an inert medium but to penetrate living cells.

There is no qualitative difference—but merely a single quantitative difference due to the respective size—between the migratory cell which penetrates a cell bigger than itself and the larger cell which "swallows" or surrounds a smaller one.

The cells which thus penetrate each other may be sister cells or kindred cells, and may belong to the same individual or to a different individual of the same species, or even, in many cases, to different genera. The destiny of one or another does not depend upon the degree of specific relationship between the plasmas in question, and neither is it always and inevitably the larger cell which devours the smaller one. We may have no less than eight different cases according to the circumstances involved:

1. A simple inclusion; thus in the infusorigenia of the Dicyemids the first spermatogonium immediately penetrates its sister cell which becomes a follicle (*Lameere*).
2. Endo-parasitism.
3. Phagocytosis.
4. Plasmogonia without caryogamy (provisory or definitive *Sponge*, and Prenant: *The Giant Cells* in *Re. Gen. de Sci.*, p. *Sponge, and Prenant*: *The Giant Cells* in *Re. Gen. de Sci.*, p. 370, 1910, etc., etc.).
5. Plasmogamy characterized by deferred nuclear fusion (the formation of di-karyons).
6. Adoption of the nucleus of one cell by the other.
7. Auto-mixia (union of nuclei proceeding from the same nuclear division, or else of sister cells or of kindred cells).
8. The conjugation of cytoplasm with cytoplasm and of nucleus with nucleus.

Endo-parasitism is in no way connected with a specific difference of plasmas—it may be observed between sister cells in the sporogonias of the *Narcomedusae* of the genus *Cunina*, and also in the axial cell of the nematogene of the *Dicyemids*. In this case a cell divides into two cells of unequal size, and the smaller of the two new cells then penetrates the larger one—the future axial cell—and there develops independently, becoming a mother cell giving birth to gonocytes.

Some of the gonocytes emigrate from the mother cell, and then from the axial cell, in order to immigrate into some peripheral cell of the larval ectoderm, wherein their nucleus is *adopted without either karyogamy or plasmogony*.

An immigrant cell, after undergoing a temporary fusion

with the cell which it has penetrated may resume its individual character, and there exist between phagocytosis and syncitial fusion all the intermediate stages, illustrated by the "polynucleated masses" of the larvæ of silicious sponges and by the syncitium of Van Beneden in the placentary villosities.

Apropos of the former, Delage has brought to our attention that stage of the larvæ of the *Incalcaria* in which all the subepidermic elements send forth pseudopods and form a network, either retaining their individuality as in *Esperella* or else losing it temporarily in the course of a demi-phagocytosis which follows upon the liberation of the ectodermic cells.

III. THE ORIGIN OF MIGRATORY CELLS

Life consists essentially of motion—its *simplest biological expression is the amoeboid cell.*

Cellular migration must have had its origin in an inequality of growth in the first living cell, whose mass increased more rapidly in the region of the space most favorable to nutrition.

But, between the cell which increases unequally in the different dimensions of space, by means of prolongations extending from a fixed initial mass, and the cell which drags along its entire cytological by means of its pseudopods, every sort of intermediate condition is to be found.

Like rapidity of growth, rapidity of migration obeys the law established by van 't Hoff for the velocity of reactions and doubles with a rise of 10 deg. Cent. in temperature. The power of migrating—*acquired originally* and basically *through inequality of growth*—has been *lost secondarily through specialization*: first, because of their grouping to form tissues, in which certain cells alone remain migratory in order to provide for the needs of the others which have become fixed, and secondly because of the acquisition of cilia, which enable the cell to dispense with movement in the surrounding medium by means of their powers of causing motion in the medium itself.

As a matter of fact *amoeboism remains an essential characteristic of every cell;* while remaining merely potential so long as it is masked by histological specialization, it exhibits itself in the less highly differentiated cells, in the sex cells especially, which, along with their other vital manifestations, faithfully retain their power of migration.

It is amoebocytes which produce, by means of lymphocytosis, karyokinetosis, or other similar reactions, the activity of Metazoan animals which are super-excited by means of toxins (Vide, "The Production of Leucocytes in Cultures in Vitro in Fragments of Spleen," *Rev. Gén. d. Sc.*, p. 3, Jan. 15, 1920).

When cultivated outside the organism, not only the hematopoietic tissues, but even such highly specialized tissues as muscular fibers, produce amoeboid cells by means of a return to the original type, by metaphanic variation.

When the cells of frogs' eggs are introduced into the peritoneal cavity of a frog they do not become differentiated, but yield cells of an indefinitely embryonic or sarcomatous character, each of which is capable of individual migration into the tissues of the host.

In the same manner the cell which becomes cancerous acquires that property of the migratory cell which enables it to insinuate itself irresistibly into the adjacent tissues there to form the cords of a tumor, and this is the case not only in animals but even in plants as shown in Figs. 5 and 6 (Vide E. F. Smith's "Studies in the Crown-Gall of Plants and Mechanism of Tumor-Growth in Crown-Gall," in *Journal of Cancer Research*, Vol. 1, No. 2, April, 1916, and in *J. Agr. Research*, Vol. 8, No. 5, 1917).

CONCLUSIONS

The amoebocyte, the simple form of the isolated cell, a temporary phase found in many cells which later become fixed and specialized, a state which always persists in some cells at least of all the higher animals—a state of equilibrium toward which there is a tendency in every cell which is produced under the influence of differentiating abnormal factors,

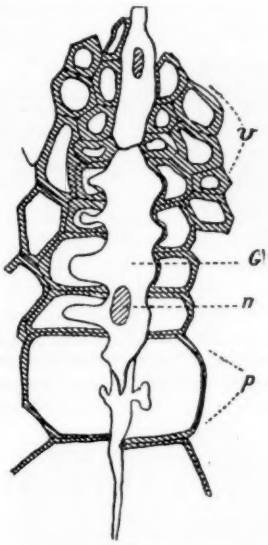


FIG. 5

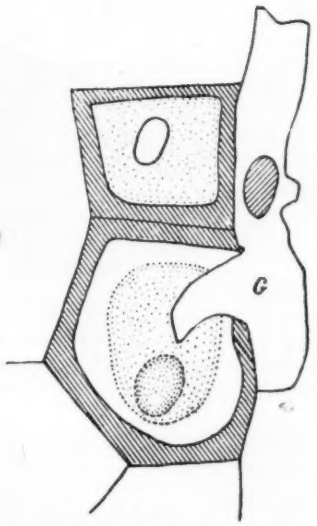


FIG. 6

Fig. 5: Cancerous cell in an experimental tumor produced in the Sylvestre pine tree. The concerous cell, G, has issued from the cambial neoplasia, inserting itself between two rows of cells, which it splits like a wedge, while the lateral walls form a hernia in the separated cells. *n*, nucleus; *p*, new spring growth of wood: *v*, autumn wood. Fig. 6: The penetration of a migratory cancerous cell (G) within an adjacent cell whose cytoplasm undergoes plasmolysis

appears to exhibit merely the *faithful image of what the original* cell was, starting from which functional specialization has molded all the others in the form of a continuous series.

THE RELATION BETWEEN GROWTH AND SAP CONCENTRATION

IN summary of experiments made to determine the relation between growth and sap concentration, Prof. Howard S. Reed of the University of California says in an article in the *Journal of Agricultural Research* for April, 1921:

(1) Observations on the growth and sap concentration of young trees showed that the two variables have a tendency to vary in opposite direction—that is to say, rapid growth is associated with a generally lower concentration of sap in that shoot.

(2) There was a gradual increase in sap concentration as the season advanced. In apricot trees the concentration continued to increase for some time after active growth had ceased. The accumulation of solutes in the plant sap is unquestionably related to the synthetic metabolism of the tree as the season advanced, though there is some evidence that diminished water absorption was partially responsible for the increased sap concentration.

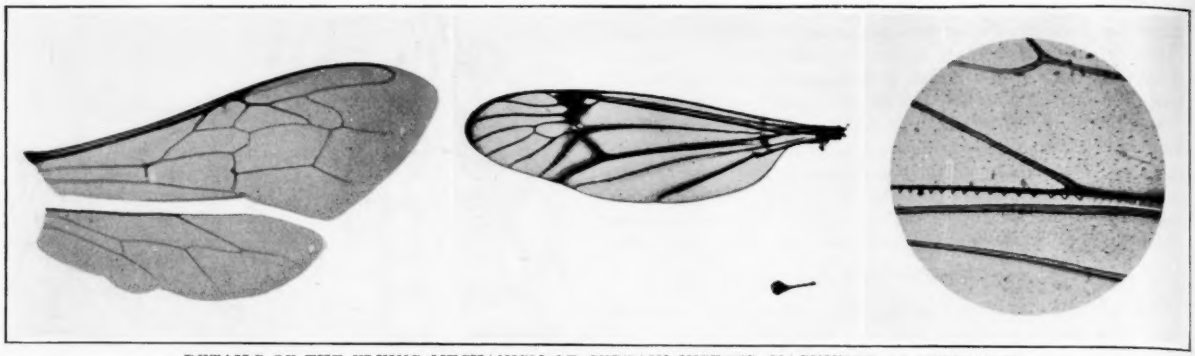
(3) Of several environmental factors measured, soil moisture was the only one having an obvious effect upon sap concentration. The addition of water to the soil usually diminished the concentration of the plant sap.

(4) The sap concentration of shoots on trees heavily pruned was lower than that of shoots on trees not pruned.

(5) A concentration gradient appears to exist in the shoot. The concentration of the sap in the apical portion of a stem was greater than that in the basal region.

(6) Lower concentrations of plant sap in the shoot as a whole appear to be associated with abundant intake and rapid vegetative growth. Higher concentrations are associated with slow growth and fruit-bud formation.

(7) The results seem to indicate that the practice of summer pruning fruit trees is not only necessary but may be detrimental.



DETAILS OF THE FLYING MECHANISM OF CERTAIN INSECTS, MAGNIFIED AS INDICATED

Left: Wings of the bee (x5). *Center*: Wings of Pachyrhina creata (x2). *Right*: In the bee, the hooks on the forewing catch on the hindwing (x30)

How Insects Fly

The Mechanism of Flight of Various Species Contrasted With That of the Birds

By E. Bade

IN the light blue haze far above the dust of the earth an eagle is slowly circling. He is nothing more than a tiny spot; the wings seem motionless when seen through the most powerful glass. He seems to float in the ether as if in an unbound ocean, carried, lifted, and pushed forward by the light atmosphere. But here flight is only made possible by the active motion of the planes. They beat upon the air and so produce a conscious lifting effect which is larger than the weight of the animal's body. Most birds produce a forward motion when moving their wings, for the wing of the bird is movable along its front length, and the posterior part gives to the atmospheric pressure. The wing, like the propeller of an airplane, pulls the body forward through the air.

The wings of the insects are built upon an entirely different principle than those of the birds. Here it is not a development of an extremity analogous to the arms of man, but it is a membranous fold of the thorax and appears, in the pupa stage, as a new formation. It has been believed that the wings of the insects originated from bushy tracheæ which were protruding from the body into the water and utilized as breathing organs. Even today a few lower forms of insects are found which possess tracheæ protruding into the water. In form they are small, wing-like, leaf-shaped appendages of the body, and observations have shown that practically full developed insects in the order of the Neuroptera use their wings for swimming around in the water. The water-inhabiting *Hymenoptera* (certain wasps) *Polynema natans*, and *Prestwichia natans* use their wings, even in a fully developed state, for the purpose of swimming about in the water.

But this theory is by no means satisfactory for it demands that all winged insects must have originated from water-inhabiting larvæ. When the order of the *Ephmerida* (May-flies) are studied in detail, it is seen that the tracheal gills are embryologically abdominal legs and therefore the thorax should have equivalent tracheal gills besides having the legs. If the new theory is to stand, the origin of winged insects, in all probability, can be found in jumping insects. Here the wings originated as an independent broadening and lengthening of the thorax—the meso- and metathorax—which later became an independent appendage. At the beginning of their development these could only act like a glider and so were able to lengthen the natural jump of these animals.

Nearly all of the insects existing today have developed from forms having two pairs of nearly equal wings, moved independently from each other, and each pair having an equal share in propulsion. This form of the wing is still found in the two orders represented by the darning needles and the dobson flies.

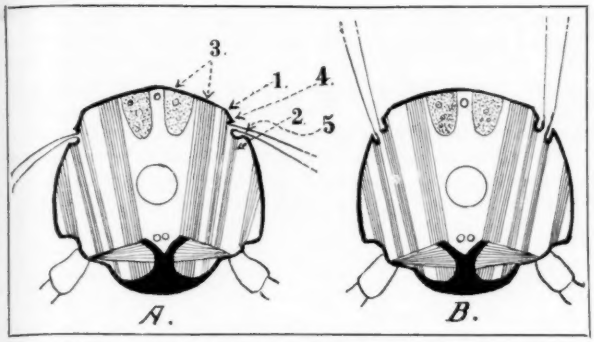
The wings of the insects developed as an elongation of the thorax; and into the more or less dome-shaped protuberance from which the wings arise, tracheæ have grown. The wings, like the rest of the exoskeleton of the insect, consist of an inner layer of living cells and an outer chitin. When the wings are fully developed the inner cells dry up and disappear leaving the outer layer as a fine thin chitinous membrane. The dome-shaped protuberance found in the undeveloped insects quickly grows in length, little in width, and not in thickness, so that it forms a much flattened sack which gradually develops into the wing.

The fully developed wing therefore consists of two very thin and connected membranes between which lie the now chitinous tracheal tubes which brace the wings and give them the desired stability necessary for flight. Such an insect wing is a master work of nature, it has great strength combined with but little weight.

When considering the flight of birds in the final analysis, it is found to be essentially a gliding motion, while the flight of the insects has a tendency to rise straight upward. For this purpose the bodily size of far the greater number is small, making a violent beating of the wings a necessity. The number of wing beats per second varies with the different species: darning needles have 28 per second, the bumble bee 220 per second, the bee 330 to 440, and the house fly 400 to 600 per second. These figures are extraordinarily high, and they are more illuminating when compared with a propeller of a flying machine which only averages about 25 revolutions per second.

The aerial dance of the mosquitoes as they rise and fall above the mirror of the pond shows this lifting or rising power very distinctly, and the rapid vibration of the air set in motion by their flight is heard as a buzzing sound.

The bird's power of flight is the direct result of muscle power, but the flight of the insects is not a result of the pressure of muscles. Here the wing roots are found at the base of the wings at the edge of the thorax and the wing receives its motion by thoracic levers which are attached to the root of the wings. When both the ventral and dorsal levers of the thorax meet each other, the wings are forced upward. This is accomplished through vertical bundles of muscles stretched between dorsal and ventral thoracic segments. Pressure at right angles, the horizontal, is exerted at



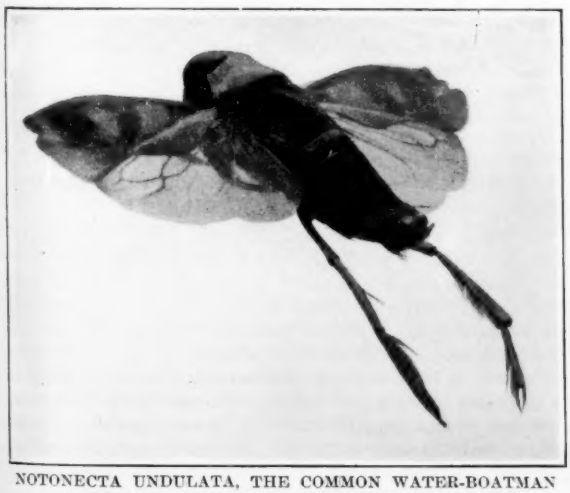
MODEL CROSS-SECTION THROUGH THORAX OF A TYPICAL INSECT

A: The extreme downward stroke, and *B*: The extreme upward stroke, of the wing. The lifting muscle, 1, and the downward-pulling muscle 2, are attached to the levers 4 and 5. The muscles indirectly used in flight are designated by 3.

the downward beat. At the same time they press a chitinous rod below the base of the wings, lift it upward, and, at the other end of the lever, the wing is carried downward. On every beat of the wings, the levers of both the ventral and dorsal side of the thorax are pressed together and forced apart again. To this motion is to be added the curvature which the wing describes. This is accomplished by tiny chitinous pieces found at the base of the wing which produce leverages more or less complicated in detail.

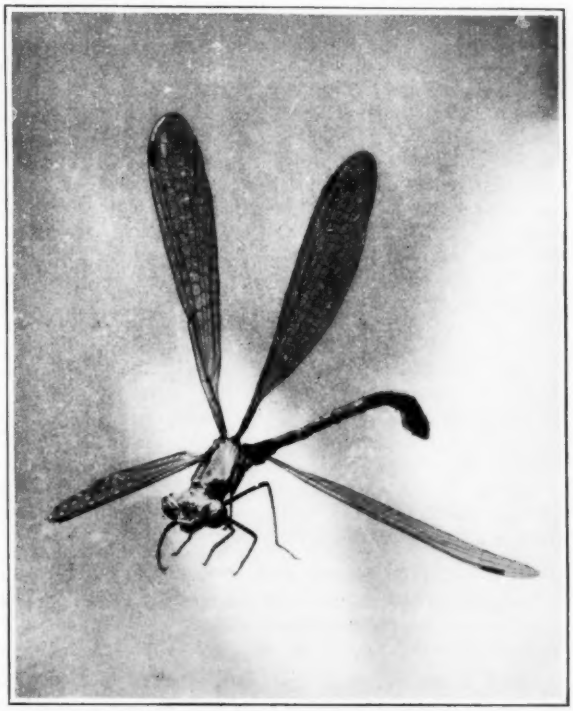
The flight of the birds is alive. Muscles, nerves, and blood vessels have their place in the scheme of things, the entire structure is under the direct influence of the will. The motions of the insect's wing is accomplished with a number of chitinous levers, one pressure in a certain direction loosens an enormous number of complicated motions. Here the entire wing is a dead formation, while the wing of the bird is built up of living cells.

The best form of wings for direct upward flight are those flat wing expanses found in the insects; curved wing surfaces are best adapted for gliding. But the insects have not enough strength for such a gliding flight, they cannot keep themselves at a constant level for any length of time. The body lies back of a point of equilibrium where all the air resistance is found and therefore these animals cannot perform a gliding flight. The birds can glide, the two wings form one surface with the body, which is not the case with most of the insects, for here the wings are attached to the body at a point. The wing can produce curves in the air without hindrance, which in the wing of the bird, is impossible. This twisting motion of the wing practically reduces the air resistance to the zero point. to this, the air above the wing is rarified which also helps to lift the body.



NOTONECTA UNDULATA, THE COMMON WATER-BOATMAN OF THE UNITED STATES, MAGNIFIED 2½ TIMES

In flight the butterflies place the posterior edge of the forewings upon the anterior edge of the hindwings. In some of the butterfly families the wings are more closely joined together. Here a strong, springy elongation, the jugum, projects backward from the base of the forewing. This lobe-like process holds the front- and hindwings closely together and also makes it possible to spread them very rapidly. In flight both wings on the same side are beaten up and down in unison. The true butterflies, or day butterflies, beat their wings very slowly while the moths, on the contrary, beat their wings with great rapidity. When the butterfly shortens the wing surface on one side by drawing one wing over the other, or by some other means, its more or less gliding flight is changed into a curving flight. Here gravity and pressure lie close together making it possible to glide toward any desired



AGRION SPEC., ONE OF THE DAMSEL FLIES

The upward beat of the wing throws the air upward and backward, pushes the air to the rear, and drives the insect forward. This is especially emphasized by the moths which are known as the best fliers of the insect world. The downward beat of the wing lifts the body upward, but in addition object such as a flower, etc.

In some insects, especially the grasshoppers, the forewings are seldom used for actual propulsion when in flight. The same is true of some of the beetles. Here the forewings have become changed by the passing of time, into thick, leathery or chitinous, hard wingcovers which protect the delicate membranous hindwings when at rest. When in flight the greater part of the beetles keep their wingcovers expanded, horizontal, and motionless with the anterior margin slightly higher than the posterior margin. These act as passive wings in the flight of these insects. It has been noticed that the June bug uses its hard wingcovers actively in flight and that they help to lift the beetle upward while the membranous wings drive the insect forward. The gold shimmering rose beetle, *Cetonia*, only lift their wingcovers to let the membranous wings come forth. They are pushed sideways from under

the covers and fly with extraordinary agility, turning and circling about the flowering shrubs.

The large fore- and the small hindwings of the bees are more closely united in flight. Here a row of tiny hooks is found on the front margin near the center of the smaller hindwing. These hook into the downward-bent back margin or depression of the posterior margin of the frontwing.

The hindwings of the flies have developed into balancers which resemble a bristle terminated by a ball. The large number of wing beats while in flight is dependent upon the small size of the degenerated hindwings. These halteres, as they are also called, seem to play a part in the direction of flight, and some say that they enable the insect to keep its equilibrium and so influence its flight.

Those insects having four wings, and where each one of them has its own independent muscles, move the fore- and hindwings independently from each other. When the hindwing has completed its downward beat, the forewing just begins it. This is easily observed in the small damsel flies, all species of Agrion in the order of the Odonata, which gives to these insects their peculiar flight. Through modifications in the beat of the wings the damsel flies are able to change the direction of their flight since the muscles are directly attached to the individual wings. The long, narrow abdomen of these insects, in all probability, acts as a rudder thus influencing the direction of flight. Here the point of equilibrium is changed by the abdomen as it moves from side to side. The same is true of the *Hymenoptera* and the *Lepidoptera*. The beetles cannot utilize this method of changing the direction of their flight as their abdomen is rigid. Here the wingcovers come into play and, by a change in their position, the direction of flight can be altered at will.

The bird can shorten its wing in flight on the upward beat by bending the arm bone, this is impossible in the insects. In order to bring the air resistance to as low a figure as possible, its wings must produce curving beats.

The most important work of the insect's wing is to overcome the bodily weight. A special adaptation of the insect's power of flight is the development of tracheal pockets which are similar to the air sacks of the birds, therefore the insects and the birds cannot be likened to a flying machine but rather to a balloon with motive power.

VARIATIONS IN THE HYGROSCOPIC ACTION OF HUMAN HAIR

By A. R. Clawson

It is a well-known fact that hair expands slightly when moistened, and that it resumes its former length when its previous moisture content is restored. This principle is the basis of the German hair hygrometers which are sold in this country and assume to measure accurately percentages of relative atmospheric humidity. But when the hair hygrometer is subjected to a series of tests in comparison with more accurate recorders of relative humidity, it is found to lack many of the essential characteristics of a reliable instrument.

An air-tight cabinet about four feet long was fitted up with a horizontal partition having an opening at either end. Coarse screen was placed over each opening. An electric fan was installed within the cabinet, producing a circulation of air on both sides of the partition and insuring a uniform humidity throughout. Through the roof of the cabinet were inserted wet and dry bulb thermometers of the sling psychrometer type. The hair hygrometers were placed in theupp er compartment as near as possible to the psychrometer. Both single and multiple hair members were tested and hairs of different grades of fineness were substituted. All hair was first treated with ether to remove any oil which would keep out moisture and so prevent hygroscopic action. The humidity tables used were the official U. S. Weather Bureau tables, computed by Professor Marvin of Cornell.

To obtain a given constant high humidity, strips of wet gauze were placed on the screens, the fan started and the cabinet closed until a percentage was reached slightly above that which was required. The fan was then stopped, the cabinet opened narrowly and the gauze quickly withdrawn. After closing the cabinet and allowing the fan to run a few minutes, the readings were taken. For a low humidity, anhydrous calcium chloride and potassium hydroxide were used. In this case the percentage obtained before removing the drying agents was slightly below that required. All readings were taken with the cabinet closed and the fan in motion.

It was found that up to about 60 per cent relative humidity the expansion of hair is quite consistent. Above that point the coefficient of linear expansion becomes slightly less. This difference was difficult to determine accurately, owing to shrinkage of the hair, which set in at between 60 per cent and 70 per cent.

In one typical set of readings, the instruments registered approximately alike up to 60 per cent. At 61 per cent the hair hygrometer registered 59 per cent. At 65 per cent it still registered 59 per cent. At 86 per cent it had risen to 61 per cent. At 88 per cent it had fallen to 55 per cent, at 91 per cent to 53 per cent, whence it continued to fall slowly for some time. The slowing up of the expansion preceding actual shrinkage sometimes began as low as at 54 per cent.

On the day after a high humidity test it was found that the hair member had partially recovered its shrinkage, leaving a discrepancy of from 4 per cent to 10 per cent. The recovery continued in constantly decreasing degree for several days. In repeated high humidity tests two days apart, shrinkage set in at a higher percentage of humidity at each trial, rising from 65 per cent to 90 per cent. Each shrinkage was less than the one preceding. After each moist exposure, the hair lost a part of its hygroscopic properties. In order to obviate any further shrinkage the hair member was subjected to a humidity of 100 per cent for thirty minutes, taken out and thoroughly dried. Upon resuming investigations next morning it was found that it had lost practically all of its hygroscopic properties.

In spite of the exceeding fineness of human hair, it is slow in responding to changes in air humidity. Time is required for the moisture to work its way in or out between the delicate cells and bring the center into the same condition as the exterior. After the humidity has become constant, the hair adjusts itself at the rate of about 1 per cent in ten minutes. No hair hygrometer reading is accurate unless the humidity has been constant for about half an hour. If the percentage of humidity is rising, the reading is too low; if falling, it is too high, the average correction being about 3 per cent. Fewer hairs in the hair member increase the rapidity of action. Finer hair acts more promptly than coarse.

From the foregoing it can be readily seen that any hair hygrometer which is graduated in humidity percentages can be only approximately correct. Hair is at best, a poor recorder of humidity. It seems highly probable that changes of length in human hair correspond to changes in absolute humidity and not relative.

A METHOD FOR ELIMINATING ATMOSPHERIC DISTURBANCES

W. Gerlach (*Jahrb. d. drahtl. Tele.*, Nov., 1920), gives a method essentially consisting in grounding a suitable point of the antenna through a detector of the carborundum or electrolytic type, so that strong atmospherics can go to ground while the relatively weak signals cannot overcome the resistance offered by such a detector. The choice of the point of the antenna is of importance for obtaining good results, as shown by diagrams given in the article. This method has allowed of reception with 4 amplifiers and a Morse apparatus through strong atmospherics, which was impossible with the ordinary antenna. Reproductions of Morse tapes in both cases illustrate the effectiveness of the system.

How Motion Affects Form*

Analogies Between the Behavior of Crystals, Fluids, Lines of Force and Living Organisms

By Karl Przibram

LIKE many other physicists, I have been profoundly impressed during the many years which I have devoted to electrical research by the manifold and remarkable analogies existing between electrical figures and the phenomena connected with extension and morphological outlines in various other realms of nature, particularly that concerned with the flow and "spread" of fluids.

Electrical figures, upon which I hope shortly to publish an extensive treatise, are peculiarly fruitful in such analogies. But different investigators have obtained different results from similar experiments. Thus De Luc concluded from the aspect presented by electrical figures and a comparison of them with the movements exhibited by fluids that electricity flows *in* at the negative pole and *out* at the positive pole, whereas a study of the same phenomena led von Bezold to form an exactly opposite conclusion.

These rather baffling contradictory results appear to me, however, to spring rather from too inadequate than too extensive a generalization of the facts observed.

To begin with we are not concerned with two special kinds of mechanism but with *all* natural processes where extension in space or "spreading" takes place, or at any rate with a very large group of such phenomena so far as *form* is affected by them. It is quite possible that a logical following out of this concept may enable us to form a comprehensive theory embracing all 3 realms of nature in a system to which the term "*General Morphology*" might properly be applied. Certain indications of such a system are already to be found here and there in Nature. We are already familiar with the widespread occurrence in Nature of "*lines of force figures*," which is by no means confined to the magnetic field and the electric field but can be recognized in an analogous manner in the electric figures and also in the figures made by fluid currents, in diffusion figures and in the division figures of organic cells. Ledus in particular has called attention to this in his *Synthetic Biology* (Paris, 1912), and very generally refers to "*dynamic centers*"; it is he, indeed, who has probably gone farthest in the search for *lines of direction* having a general morphological significance. The similarity in form of the figures cited is to be ascribed to a similarity between the static or stationary phenomena observed. I should like on my own part to call attention to a connection no less general which exists between *form* and *rapidity of spread* although the basic analogies concerned cannot as yet be reduced to a mathematical formula. Let me begin with a very trivial example. If a drop of ink be placed gently and carefully on a sheet of paper it forms a perfectly round spot, but if on the other hand it be slung forcibly from the point of the pen it spatters and spreads, producing a spot with curved or with jagged edges, or with long tongues extending from it according to the varying circumstances of the case. An increase of velocity is evidently here concerned with the rounded or irregular form of the figure and this can be demonstrated by a whole series of similar phenomena. Closely related to the example just mentioned—figures produced by spattering—are the instantaneous figures of falling drops obtained by Worthington which exhibit the more exaggerated spread made by an increase in the height of the fall which, of course, implies an increase of velocity. Among such examples there also belong the figures obtained by Decharme through the falling of drops or jets of liquid on glass plates upon which red lead has been strewn and which he compares with electrical figures. According to his observations where the liquid falls from a small height concentric rings are chiefly formed, while when the height of the fall is increased jagged figures with radiating projections are formed.

The relationship which exists between form and velocity is exhibited very beautifully in the "*tearing figures*" produced experimentally by R. Arti (*Vide Ark. f. Mat., Astr. o. Fys.* 8, No. 14, pp. 1-11, 1912) and compared by him both to electrical figures and to the dendrites seen in metallography. When a viscous fluid is enclosed between two glass plates and the latter are then suddenly separated, the fluid between them forms dendrites, *i.e.*, branching tree-like figures, and according to Arpi's experiments the greater the rapidity with which the plates are separated the finer the division or branching seen in the figure will be. When the plates of glass are pulled apart slowly the outline of the figures produced by the liquid are straight or but slightly curved. The similarity between these slowly formed outlines, and those of a negative electrical figure is very striking, while that between the outline produced when the plates are rapidly separated is equally remarkable in its similarity to a positive electrical figure.

The present writer came to the conclusion many years ago that the positive electric figures spread out with much greater rapidity than do the negative ones (*Wiener Ber.* 108, pp. 1161-1171, 1899). This belief has received fresh support very recently by the Danish scientist, P. O. Pedersen, who has furnished direct proof of the fact and has succeeded in measuring the velocity of the spread (*Dansk. Vidensk. Selsk. Math. fys. Medd. I*, 11, pp. 1-76, 1919). According to this authority the velocity of spread was from 2 to 4 times as great in the case of the positive figures as in that of the negative ones. Thus, in this instance also it is evident that where the act of spreading takes place more slowly, the form is more rounded in character, as shown in the negative electrical figures, whereas a greater rapidity of spread produces the more branching and radiating form seen in the positive electrical figures.

As we indicated above Arpi has called attention to the similarity of form between various structures exhibiting the dendrite or branching outline, and especially to the crystalline dendrites seen in metals. In such cases likewise, there is a direct relationship between the form of the crystal and the rapidity with which it was produced. It is a well-known fact, indeed, that the formation of crystals of regular form depends upon the slowness with which the crystal is produced, whereas when the growth of the crystal is greatly accelerated (as when the solution is rapidly evaporated or rapidly congealed), the crystal tends to form dendrites or a skeleton outline, such as is shown in the crystallizing dendrite found in cast iron. Thus we see that an increase of velocity is connected in this case also where the matter is complicated by the forces concerned in crystallization with a radiation or stretching and branching of the form finally produced.

The common principle involved in these extremely various mechanical processes concerned in the act of spreading or extension, is probably to be found in the fact that when a spread or extension has taken place in a given direction, an increase of velocity favors an increase of the spread in the said direction.

This holds good for the spread of a sluggish fluid just as it does (because of the peculiar deformation of the electric field) in the case of electrical figures (Vide M. Toepler, *Phys. Zt.*, Vol. 8, pp. 743-748, 1907).

But according to O. Lehmann the formation of the framework of crystals is also to be explained by the fact that as soon as an extension or point has been formed, continued growth at the same point is favored by reason of the alterations

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in the diffusion relations. This tendency to follow an initial path once opened, which leads to the formation of radiated, branching forms, is the more strongly accentuated the greater the velocity with which the extension follows the aforesaid paths, since it is less easy to open up adjacent paths—particularly when there is great resistance offered to the forming of such new paths—and just here there is exhibited a further analogy or coincidence among the examples cited: in the case of electrical figures the greater the electrical tenacity of the medium in which they are produced the stronger their tendency to confine themselves to single branches. Thus in fluids which are poor conductors one is able to obtain only figures composed of a few thin serpentine lines and none of the plane figures such as the negative figures in air. According to Arpi the "tearing apart" figures are increasingly fine in their divisions in proportion to the tenacity of the fluid employed; while O. Lehmann observes that the formation of the framework in crystals is favored by an increase of viscosity in the solvent medium (gelatine).

Still another series of phenomena is probably to be regarded as belonging in this category—namely the figures produced when one liquid spreads out over the surface of another. These have been pretty thoroughly described by Tomlinson (*Phil. Mag.* (4) 22, 249-261, 1861; 23, 186-195, 1862; 27, 425-432, 1864; 28, 354-364, 1864); but since he makes no observations as to the velocity of the spreading action, and since the process was strongly influenced by the presence of various small impurities his results cannot here be employed to support our thesis without further inquiry. It is very doubtful, likewise, whether the relation between form and velocity holds good in the case of the dendrites found in many kinds of rocks by the oozing of water into them, since in such cases the outline of the figure is obviously indicated to some extent by the distribution of the pores in the rock in question. This question might be answered conclusively, however, by means of a series of experiments dealing with the penetration of porous substances by liquids subjected to various degrees of pressure.

Another example, which would appear to contradict the theory we are trying to establish, requires to be mentioned: namely, the well-known fact that when a stone is thrown with a low degree of velocity through a pane of glass the latter is shattered, the aperture produced being surrounded by numerous radiating cracks whereas a bullet makes a smooth round hole; while according to our hypothesis exactly the opposite result should be produced. We regard the system of cracks in the glass as representing the figure due to the spreading prematurely interrupted. In spite of an increase in the tension (velocity) the figures become smaller in this case, since in the resultant discharge of sparks the inducement to a further growth is lessened (complete discharge of the electrode).

An example of a very perfect analogy to the instances cited above is the equally familiar fact that a sheet of asphalt or pitch can be shattered by a sudden blow, whereas on the other hand a ball can be made to penetrate it without shattering it if slow pressure be employed. We may compare with this the observation made by Holtz and by Reitlinger to the effect that the *positive* Lichtenberg dust figure which exhibits the well-known branching radiated form when an electrode which is a good conductor is employed, exhibits an approximation to the non-radiated rounded negative form when a semiconductor (*i.e.*, a wooden rod) is employed instead—that is, when there is a retardation in the flow of electricity.

Considering the very extensive analogy which exists between crystals and living organism it seemed *a priori* not improbable that the connection between form and velocity which we have demonstrated to exist in the former might also be present in the latter. I am indebted to Mr. L. Portheim and Mr. H. Przibran for a proof of this in the following examples which it seems probable might be greatly extended, but which are in themselves quite sufficient to prove the extensive application of the principle in question.

In the investigation of the cases in point, observations and experiments have been made with respect to difference in rapidity of development in individuals of the same or of related kinds. Thus it is a well-known fact that in the case of many sorts of plants the development of the stem is much more rapid in specimens grown in the dark than in those grown in the light. Such '*etiolated*," *i.e.*, pallid and yellowish plants furnish an excellent example of this principle, because the plants which develop under the influence of light show a forced structure with an extensive development of leaf surfaces, while those grown in the dark are generally tall and thin of stalk, while the surface extension of the disturbed foliage is very much less in proportion than the growth in length of the stalk. With respect to this L. Jost makes the following observation: "When we compare an etiolated specimen of *dahlia variabilis* with one which has been grown under the influence of light we find that in the former both the internodes of the stem and also the leaf stalks are inordinately lengthened, while the leaf surfaces, on the other hand, are comparatively small and undeveloped." But according to Wiesner (1891) and Brenner (1900) even in the so-called "rosette plants" such as *sempervivum* (live for ever) the etiolation may consist in a decrease of size in the leaves and in a stretching or lengthening of the otherwise compressed internodes and, therefore, in a disappearance of the leaf rosette. In this case an increase of humidity produces a very similar effect. Many monocotyledonous plants in which the stem is ordinarily more backward in growth than are the leaves, "form in the light as well as in the dark comparatively long sprouts; the leaves, on the other hand, are subject to a marked and excessive increase of length, because of the sustained activity of their basic vegetation point, but remain in general narrower than in the light; therefore, we have in this case also an elongation of the entire form.

In many fungi also the etiolations consists of a marked elongation of the stalk and a corresponding diminution in the "cap" of the mushroom even to such a point that the latter may be entirely missing. An increase of temperature exerts an effect similar to that of darkness, increasing the rapidity of the growth as a general thing up to an optimum point.

A very fine example of the fact that favorable conditions of growth tend to produce more finely divided branch and forms, is afforded by the common fern, *polypodium vulgare*, which appear in two forms: In the normal form the outline of the leaves is lanciolate with simple, deep clefts between the leaflets, while in the second form the leaf is much more finely divided and more abundantly branched. If the latter form is removed to an unprotected location in dry and sterile ground, the coarser normal form again makes its appearance (Goebel). Here, too, the retarding of the growth has resulted in a simplification of form.

In the case of amphibious plants two different kinds of leaves are found upon one and the same individual; those leaves which grow under water are usually much more finely divided than those which grow above water, as in the case, for example, of the *Ranunculus aquatilis*. Unfortunately we lack data in this instance, as to rapidity of growth. Here we have an example in which our assumed morphological principle may indicate whether it is useful upon occasions or whether it must be regarded as showing a considerable narrowing of its dominion. Our assumed principle leads us to expect that the sub-aqueous leaves grow faster than the aerial leaves, but this question must be decided, of course, by actual experiment.

If we turn our attention now to examples among animals we find an analogy to the "warmth etiolation of plants in the case of rats and mice raised in an atmosphere of high temperature (implying a more rapid growth). Under such conditions these animals exhibit a more elongated structure with legs and tails of comparatively greater length; this is analogous to the observed fact that as a general thing races of animals living farther to the south tend to be distinguished by longer extremities.

W. O. Ostwald observed in a species of crab, *Hyalobachina*, a transformation of the broad, short, carapace of the head into a long pointed form by means of an increase of temperature (involving an acceleration of growth). In another kind of crab, *Artemia Salina*, W. J. Schmankewitsch observed an accelerated growth accompanied by an increase in development of the pointed tail lobe and of the terminal and lateral bristle of the tail, in proportion as the degree of concentration of the salt water medium was decreased.

The observation made by C. Paronas that the dorsal appendages of the snail (*Tethys leporina*), which normally have a simple spindle shape, regenerate themselves in a successful case of autotomy in a cleft or branching form is to be connected with the increased rapidity of growth which takes place when a member is regenerated—this being the only case of a formation of multiples due to regeneration, which cannot be attributed to a break and a regrowth of the broken surfaces.

Other instances which may possibly be classified under this principle are as follows: The formation of long horn-like or antler-like excrescences in tropical insects; the frequently grotesque forms of the rapidly growing feathers in the mating plumage of many birds; the fact that stag's antlers with their characteristically branched forms are among the most rapidly growing structure found in the bodies of mammals—in this connection it is worth noting also, that a single true horn which is shed yearly like a year's antler, and is, therefore, obliged to grow rapidly, *i.e.*, that of the pronged-horned goat, is forked.

Observations with respect to the influence of temperature upon the form of the wings of butterflies do not appear, however, to be classifiable under this principle: while a swallow-tail butterfly reared in the cold exhibits, as this principle would indicate, an abbreviation of the tail of the rear wing, it is found, on the other hand, that either heating or cooling causes an elongation of the tails in another butterfly. . . . It is the chief purpose of these lines, however, to indicate the possibility of a more generalized point of view with regard to many questions in morphology, rather than to precisely define the limits within which the present principle is operative.

SUMMARY

There is a definite relation between form and rapidity of expansion in an entire series of phenomena having to do with physical expansion. Such for instance, as the spattering figures and tearing figures made by liquids, electrical figures and the formation of the lattice or framework in crystals. The principle involved is that greater rapidity of formation produces a more extended radiating and branching form, while a smaller degree of velocity corresponds to a more compressed, more rounded and less branching form. This morphological principle appears to hold good, also, in the many phenomena of growth in organic nature, as in the etiolation of plants, the two-leaf forms of the polypodium, "heat rats and mice," differing forms in the hyalodathnia, artenia, and tethys, and stags' antlers, etc.

The Behavior of Crowds*

The Application of Mass Psychology in Explaining Phenomena

HITHERTO the science of psychology has confined itself to the study of individuals. And yet a knowledge of the psychological processes which sway masses of individuals or "crowds" is of great import, not only to psychologists but to sociologists, politicians and even to soldiers. Finally, a technical psychologist, Dr. Walter Moede, has recently demonstrated that the modern method of studying psychology experimentally and statistically can be applied to crowds as well as to individuals. In his new book *Experimentelle Massenpsychologie* (Experimental Mass Psychology) he throws fresh light regarding this matter upon many branches of our social existence, and it is noteworthy that in many cases our ordinary empirical practice is based upon sound psychological principles. The experiments in question made use of Leipzig students and Sorau school children as subjects and were thus, of course, confined to so-called *classified masses* while *chance or haphazard masses or crowds* have thus far not been dealt with experimentally.

The basic concepts upon which mass psychology rests may be briefly stated as follows: Those borders or limits where one individual either begins or ceases to exert an effect upon another, are designated as *collective thresholds*. This effect is most plainly exhibited in the "collective instinct" which is effective in united action. When the person conducting the experiment lifts his arm, the arm of the person subjected to the experiment is twitched in the same direction, as has been proved beyond a doubt by measurements made with the Sommers apparatus. If the arm of the leader is moved downward there follows either a similar motion or an opposite motion on the part of the subject. These experiments find a parallel in the common occurrences of our daily life. In the same class of phenomena are the sympathetic yawning, weeping, and motions of various kinds, which may be observed among the spectators at football games, for example. There is a well-known jest sometimes perpetrated by a practical joker who, by taking a bite out of a sour pickle in the presence of an orchestra of wind instruments can cause all the performers to stop playing through instinctive sympathy, since his action occasions such a strong sympathetic motion that not one of them is able to go on blowing his instrument.

When an *order* is given, the subject or subjects are required to perform some act or make some motion at the same time. The motion made by the person in command is echoed by those under his orders. In the case of the leader of a squad of persons performing gymnastic exercises, for example, the command is really given only in order to regulate the synchronous motion. Acoustic stimuli, such as counting aloud or clapping the hands can also be added, so that a rhythm is produced controlling both the eye and the ear.

The phenomena of expression at once become a bond of united action between living creatures. For our very aspect, our gestures, and even the speech which makes possible intercourse between human beings are based upon the fact that not every smallest alteration of circumstances in the world about us is capable of stimulating us to a reaction, but that on the contrary, the collective threshold must first be crossed.

In every person experimented upon differences are found according to whether he or she is working *alone or with a crowd*. This difference is known as the "*collective valence*." It has been found that when the same experiment was repeated after a lapse of weeks or of months, that the work done by the same persons improved or deteriorated with respect to the separate work in the same way as formerly within the crowd. The counterpart of the collective threshold is formed by the "collectivistic threshold," the degree in which the *individual sensitiveness* becomes altered when the individual works under collective conditions, *i.e.*, together with another person or with several others.

In order to investigate collectivistic thresholds, Moede required the subjects of the experiment to compare and describe the *intensity of the sounds made by falling balls*. The results of these experiments showed that united action is capable of

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exerting an inhibitory as well as a stimulating effect—in other words that concerted action by a number of persons may be either improved or made worse than that of separate individuals by the mere fact that it is concerted in character. The best observers are disturbed and distracted through being in a crowd, so that the work done by them falls off in quality or quantity, while the work of the poorest observers, on the other hand, improves correspondingly—in short, when all are working together, the work done by each individual tends to approximate that of the others. Since the poor work is in large part due to a lesser exertion of strength the collective working has a favorable effect. But unfortunately, the diminution in the work of the better members of the group overbalances this improvement, so that in this experiment *group working was found, on the whole, to have less favorable results* than that of the separate individuals. The view of theoretic mass psychology, that the crowd is less capable intellectually is thus confirmed by actual experiment.

The sensitiveness to pain was tested by means of an electric current. The presence of the crowd and also the feeling of rivalry experienced by each, with respect to his schoolmates, causes a *diminution in sensibility* to pain, because of the fact that each pupil has an ambition to distinguish himself as a special hero. Evidence of this is found in the experiences of war as well as in those of sport: When in a crowd the pain of individuals is suppressed and often not even felt.

The *will power* of individuals in the crowd was tested by making dots, addition and pressure upon a dynamometer for showing hand-pressure, etc. In this case also the best in the class showed a falling off and the poorest an improvement. In the dot-making test the individual pupils expressed themselves characteristically, but in the crowd they found the work pleasanter than when working alone. The rhythm of the dot-making work, which requires as large a number of dots as possible to be put on a piece of paper within a given length of time, tends to produce unity and uniformity when done in a crowd. Rhythm, indeed, appears to be of great importance in crowd action as shown in the marching step of soldiers, in the rhythm of the sweep of oars by rowers, and in hammering, etc., by a group. Moede tells us that it is possible in the dot-making test to increase the yield of the poorer pupil so that it amounts to double as much as the diminution in yield in the better half of the pupils and this sounds most hopeful.

Some of Moede's tests possess great significance likewise in the domain of the *psychology of labor*. In the united work of tested couples who had been paired with as close an approximation as possible with respect to their abilities, the capacity for work can never be found by mere addition of the individual capacities, as can be done in the case of a machine provided with two motors, and the same thing holds true of the work done by entire groups—namely, their total capacity for work cannot be found by reckoning the sum total of their individual capacities. The consciousness of united action in a crowd, especially when groups are animated by rivalry with regard to each other, inspires each individual to stronger effort. Self-confidence, self-reliance, and self-consciousness all become more intense and each individual feels more certain of himself when acting as a member of the group. On this account *group rewards* may be made effective in industry to *inspire greater effort* on the part of the laborers, provided, of course, the laborers do not *purposely inhibit* their efforts in order not to injure weaker groups.

Of great sociological importance from the psychological point of view is the result just mentioned, because of the fact that it disposes of the objections raised by Simmel against a special mass psychology. Simmel has formulated the following social-psychological problem: What modifications do the psychical processes of an individual undergo when he is acted upon by certain influences through his social environment? Such a statement of the question would make mass psychology superfluous, for this problem is to be solved within the limits of the psychology of the individual. Moede's demonstration that the united action of two or more persons produces larger results than the mere addition of the separate psychical processes and that, therefore, a new unit comes into play, contradicts by experiment Simmel's hypothesis and supports the view of Le Bon and other authorities upon crowd psychology that psychological bonds are created among crowds.

The tests of the power of attention made by Moede also support Le Bon's opinion that the mass or crowd can produce more as regards quantity but remains at a disadvantage compared with individual work as regards quality. The limits embraced by attention were tested by the marking and writing down of figures and the duration of attention by the striking out of certain letters in a given text during a period of five minutes. *Tests of memory* were likewise made. The learning in chorus of a series of meaningless syllables showed a marked increase in the power of memory—no less than 33 per cent—as compared to that by individuals learning separately. Tempo, rhythm, and emphasis have a very strong influence in unifying the crowd. That which was learned separately was forgotten twice as soon as in collective work.

The interesting question has been raised as to what constituents of memory rise to the surface first in individual work and group work respectively. Dr. Moede made use of a key-word, requiring his classes to write down the association words formed in the mind consecutively. In this case the crowd performance was inferior to the individual work—the power of association being evidently much more active in separate than in collective work.

It is a noteworthy fact that in the crowd association words make their appearance which are controlled by considerations of usefulness. The key-word *stairway* suggested for example, in the course of the mental process the following words: climb, step, wood, house, bank; the key-word *sail* was followed by the words: travel, ship, boat, patch (*i.e.*, to patch a sail); the word *house* by live (dwell), yard, door, ground, etc.

The total result of these association tests indicated a stress on the emotional side of the nature in the case of crowds, and upon the intellectual side on the contrary when individuals were concerned. Here, too, Le Bon was supported in his theory that *in a crowd the intellect is inhibited or even ceases to function*, and that because of this a uniform basic mood is created in the crowd, and that this is preliminary to concerted activity, being necessary to make the latter possible.

The test with respect to the capacity for *free creation of thought* was especially peculiar in its results. The pupils in the class were told to write down all the words which occurred to them within the space of five minutes. So far as the number of words was concerned the individual yield was superior to that of the crowd. Individuals made longer lists of associated words when working alone than when working in a crowd. The individual was obviously disturbed and inhibited by the presence of the other members of the group.

It was further demonstrated that external word-associations predominate in a crowd. In the latter the association of the words was most of all governed by patriotic emotions, whereas in the case of individuals the connection between the words was of a moral or religious nature. In this exercise of making lists of words therefore the community of feeling among the workers is clearly indicated. In these tests and others of similar nature individuals exhibited a greater degree of perseverance, cautiousness and discretion, while in the case of the crowd the process of thought was more desultory and the reactions more reckless in nature.

It cannot be denied that the science of crowd-psychology has made a great stride forward through these fundamental investigations, which are of such great import with regard to collective work, whether the latter be in church or in school, in the workshop or the marts of commerce, or on the field of sport. Much ore remains to be passed through the furnace and many a vein is yet to be explored. But at all events the day of more or less barren speculation lies behind us and we are now ready to study these questions in detail.

Industrial Applications of Ozone

How This Is Produced on a Commercial Scale and Where It Is Used

By Ismar Ginsberg

IN 1783 the Dutch philosopher Van Marum, during the course of his experimentation with electrical phenomena, marked a peculiar odor in the neighborhood of his electrostatic machine, when it was operating. In 1801 Cruickshank noticed that the oxygen gas that he obtained by passing the electric current through dilute solutions of acids, possessed a queer penetrating odor. These are the first two recorded observations of the existence of the substance that is known as ozone. Neither of the two scientists, however, gave any further thought to the matter and made no attempts to determine what the nature of this odoriferous substance was. It was not until 39 years later, in 1840, that the German chemist Schoenbein investigated the matter further and found that the smell that was noticed in the air, when the latter was subjected to the discharge of an electric spark, was due to new gas, which he called ozone from the Greek "ozo" to smell.

The work of later investigators determined that the gas ozone was formed from the gas oxygen in accordance with the following equation: $3O_2$ equals $2O_3$. The significance of this equation is that three volumes of oxygen will give two volumes of ozone under suitable conditions. In the transformation, energy is consumed, which means that the potential energy in the ozone formed is greater than that in the original oxygen. This is manifested in the oxidizing powers of the two substances, for example: ozone is a much more powerful oxidizing agent than oxygen. It is seen that in the formation of ozone, no other substance is used but oxygen. Ozone is really oxygen in another form. It is what the chemists call an allotropic form of oxygen. The sole difference between the two substances is that the smallest physical unit of the gas ozone, that is the molecule of ozone, contains three atoms or three smallest chemical units of the element oxygen, while the molecule of oxygen itself contains only two atoms of the element. While this may appear to be a very insignificant difference, nevertheless it endows the ozone with very important and advantageous properties, which make it a very useful industrial reagent in many operations and processes of commercial importance.

Ozone has always existed in the air and some of the properties, which we assign to clear fresh air, are due to the ozone that is contained therein. Its presence in the atmosphere is traced to the electrical discharges during thunder storms, whereby the discharge of electricity, manifested in lightning, converts a part of the oxygen in the air to ozone. This gas is also produced in the combustion of fuels and in the slow oxidation of organic matters, as well as of certain metals, such as iron, zinc and lead. It has been found that the air contains variable quantities of ozone. In the summer time, when electrical storms are more frequent, the air contains considerably more ozone than in the winter time. Furthermore, the ozone in the air seems to increase with the altitude. The freshness and invigorating odor in the air after a storm are supposed to be due to the ozone that had been formed anew by the lightning. The bleaching of linen, when exposed to the rays of the sun, is said to be caused by the atmospheric ozone.

As we have mentioned above, ozone is a gas. It possesses a very penetrating queer odor, which has been characterized in many different ways by scientific observers. Some say the odor resembles that of sulfur, others claim that it is like phosphorous and chlorine, and still others state that it reminds them of the lobster. The odor of the gas can be detected in a dilution of one part in a million parts of air. It is colorless, but when viewed in a column of air about 5 or 6 feet long, it appears to have a bluish tint. The blue color of the summer sky is said to be due to the considerable quantity of ozone in the atmosphere at that time of the year. The principal chemical property of ozone is its strong oxidizing capacity. In this action, the ozone is converted into oxygen, while the substance that it acts upon combines with the one part of oxygen that the ozone loses. This property of the gas makes it a very powerful germicide.

There are several methods of producing ozone. It is formed during the course of many chemical reactions, as in the decomposition of persulfates, permanganates, peroxides, etc. It is produced in the slow oxidation, known as autoxidation, of various organic materials and of certain metals. It is formed by the thermal method, in which oxygen is subjected to heat under certain conditions, resulting in its conversion into ozone in the presence of different catalysts. It results from the electrolysis of various electrolytes, in which process the electric current is passed through dilute solutions of different acids, bases and salts. It is found in the emanations of the ultraviolet light. It can always be smelt in the neighborhood of quartz mercury vapor lamps. Finally, it is formed by means of the silent electric discharge. This is the sole method of producing ozone, which is of any commercial importance.

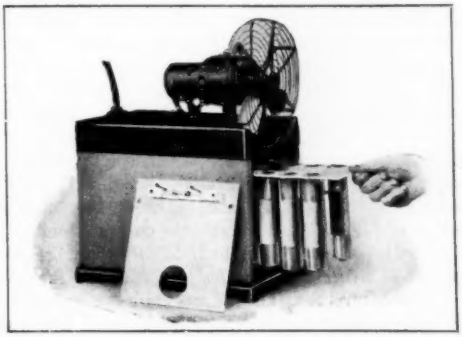


FIG. 1. TYPICAL OZONATOR OF THE TUBULAR TYPE

The industrial ozonizers are of two types, viz., one in which the silent discharge passes across the air gap without the interposition of any solid dielectric or non-conductor, and the other in which one or both of the electrodes are protected by some suitable non-conducting material, which is usually glass. The first type of ozonizers may be dismissed in a word. Attempts have been made to construct practical machines of this type, but these have been unsuccessful up to the present time, as the efficiency of these machines has always been too low to render them of any practical value. All the modern industrial ozonizers contain dielectric material.

There are two forms of machines in general use, viz., the tubular ozonizer and the plate ozonizer. The latter type is divided into two classes, those that are air cooled and those that are water cooled. In the first type of machine the ozone is formed by drawing the air through a series of tubes in which the silent electric discharge takes place. The tubes consist of an aluminum inner tube and a glass outer tube. The tubes are surrounded with water. Sometimes oil is used instead and enameled iron instead of aluminum. The plate ozonizers do not require the use of water as the radiation surface is large and the cooling effect may be obtained by the use of a current of air passing through the machine. The plates in the air-cooled plate ozonizer are made of glass and aluminum. In the water-cooled plate ozonizers the cooling is accomplished by means of running water.

Fig 1 shows an ozonator of this type. The tubes are shown exposed. The air enters at the bottom through suitable openings, and is made to pass through the space that exists between the concentric oxidizing tubes, where it is subjected to the electric discharge and part of its oxygen thrown into the ozone form. The ozonized air is drawn out of the apparatus through an opening immediately below the electric fan, and the latter drives it into the room to mix with the general atmosphere. Fig. 2 shows the tubes of a smaller machine, having only two tubes in place of the eight of the larger model. It is designed for household use; the other is for warehouses, auditoriums, hospitals, etc.

In cold storage rooms, where it is desired to move the ozonator about, the arrangement shown in Fig. 4 is very

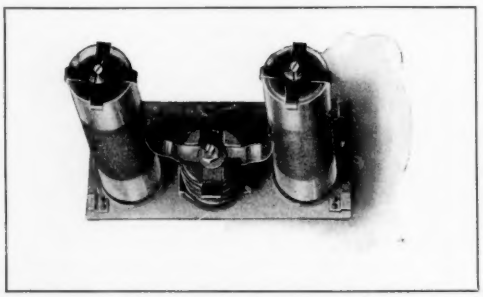


FIG. 2. A SMALLER MODEL FOR HOUSEHOLD USE

advantageous. The machine is mounted on a hand truck, with cord and plug attachment and knife switch. The ozonator on this truck will give about 700 milligrams of ozone per hour with a current consumption of 45 watts.

Another interesting installation is the water purifier for use with swimming pools and drinking water. Fig. 6 shows the internal construction of this. In the ozonator part of the apparatus at the left, *a*, *a*, *a* are removable trays containing calcium chloride. Air enters at *b* and in passing over these trays gives up its moisture before it reaches the generator tubes *c*, *d*. In the back of the casing there is placed a transformer *h* by means of which the line voltage is raised to the potential necessary for the operation of the ozonizer. The inner and outer tubes are plainly seen. Between them is maintained an electrical brush discharge. Air is drawn out of the apparatus through the pipe *e* by the pump *p*. This pump is provided with two cylinders. The air from the

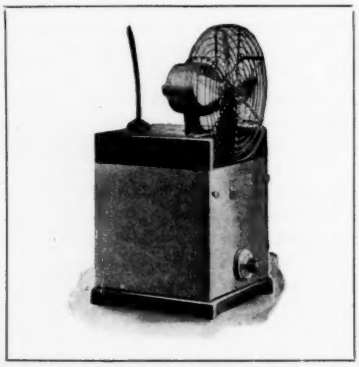


FIG. 3. ANOTHER SMALL OZONATOR FOR HOUSE AND OFFICE

ozonizer enters the cylinder *f* and is pumped into the base of the tower T. The cylinder *g* receives the water that is to be purified, and this too is pumped into the base of the mixing tower. The pump is driven by a motor and forces one cylinder full of ozonized air and one of water into the tower at each revolution. The mixing tower is a cylindrical pipe about six feet in diameter. The water and the ozonized air are mixed therein very thoroughly, the air bubbling through the water and escaping through the opening *k* at the top, mixed with the water.

Ozone has been used for a long time to purify water. It was found that water, treated with this gas, improved in taste very considerably and the impurities, contained therein, were completely oxidized, with the production of a water that can be used for alimentary and industrial purposes of all kinds. Another common use of ozone has been in the purification of air in underground passages and railways and in various public buildings, such as railway stations, theaters, etc. In order for the ozonized air to be real beneficial to the human beings who breathe it, the gas must not be present in a concentration of more than 0.11 to 0.12 milligrams per liter. The ozone undoubtedly removes the unpleasant smells which are associated with crowded places when present in this concentration, but when it is found in greater quantities, then its oxidizing action is so strong that the ozonized air has a deleterious action on the respiratory passages of the human body. The general opinion is that the presence of ozone in the air tends to destroy the disease germs that may exist therein, and it is curious to note that during the recent influenza epidemic in London, which was a part of a worldwide plague arising from the destructive results of the war, the drivers of the electric trains in the London underground railways were all immune from this disease, which was attacking both the high and low without distinction. It was conjectured that the reason for this was the fact that these workers were constantly breathing in an ozonized atmosphere all day long which rendered their systems very resistant to the influenza germ.

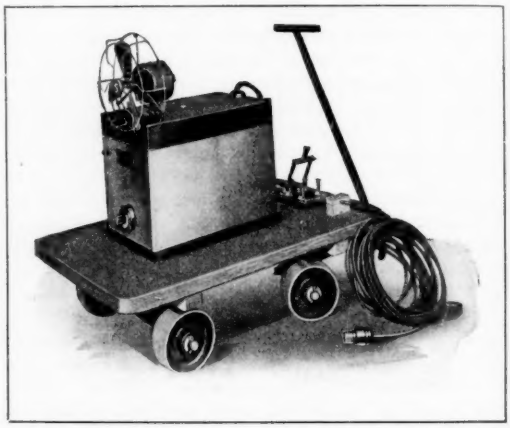


FIG. 4. PORTABLE OUTFIT FOR WAREHOUSES, ETC.

During the war the use of ozone for surgical and therapeutical purposes was given a great impetus by the difficult conditions of properly sterilizing wounds and counteracting infections in the military hospitals. In many of these hospitals small portable ozonizers were used. The results that were obtained in the sterilization of wounds by causing a current of ozonized air to pass through the cavity or sinus, were very excellent and gratifying. The first result is an increased discharge of pus, which was gradually replaced by a clear serum. The application took place twice a day for a maximum time of 15 minutes each. In all the cases treated in this manner success was attained in practically 100 per cent.

Another use is in the treatment of inflammation of the lungs. After potassium iodide had been introduced into the lungs, ozonized air was breathed and a reaction resulted in which free iodine was liberated. Ozone has been used for the disinfection of the intestines in cases of enteritis and dysentery. An important application of ozone is in the treatment of pyorrhea and ulcers in the teeth. Ozonized vaseline and other ointments have appeared on the market and are said to possess very marked advantages over the ordinary ointments. It appears that ozone is soluble in the oils that are used to make these ointments, and naturally it endows these products with a

germicidal activity which the ordinary salves do not possess. Ozone has been used in the treatment of anaemia, due to the fact that it has the property of stimulating the production of the red blood corpuscles. In asthma and heart trouble, where a shortage of oxygen is experienced, the use of ozone has been fraught with considerable success.

The use of ozone for this purpose is by no means new as far as the various textile fibers are concerned. However the application of this property of ozone in the oil, fat and wax industry is of more recent origin. There are a great many purposes for which ozone can be used in these industries besides the bleaching of the product and the improvement of its color thereby. In the case of fats and oils, which are to be used for food, a considerable improvement in flavor and taste can be achieved by the use of ozone as well as an improvement in color. Ozone has been very useful in the refining of oils and fats, which are intended for soap making. The bleaching of wax has been accomplished by the use of ozone, whereby a charge of matted wax, weighing about 11.3 kgs. and contained in a vessel, provided with steam heating coils, was bleached within 4 to 5 hours. In this process an installation of ozonizers, possessing twelve tubes in all and giving 12.5 grams of ozone per hour, was used.

In an installation of an organizing equipment used for the above purposes, the air that is admitted to the apparatus, is first passed through a cleansing device, where all the dust and

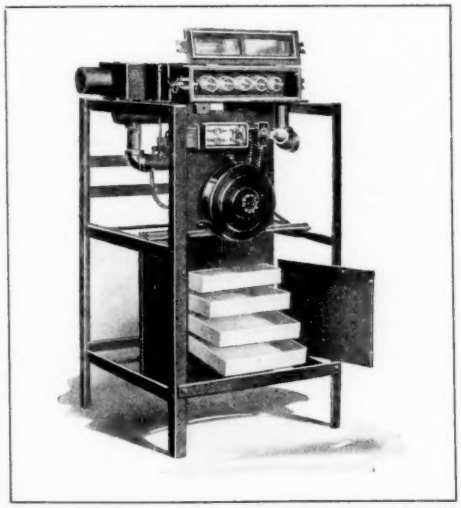


FIG. 5. TWO UNIT MACHINE FOR INDUSTRIAL PURPOSES

foreign matter of all kinds are removed. Then it is blown by means of a fan through an air-cooling machine and thence through the ozonizers. The ozonized air is then blown through the molten fat or oil through a perforated pipe which opens out under the surface of the oil.

OZONE IN THE PAINT AND VARNISH INDUSTRY

Ozone is of particular use not only in the manufacture of paints and varnishes but in their application as well. Ozone destroys the chlorophyllic constituents that are contained in industrial oils and waxes and that are responsible for the color of the same. Consequently, its use has been proposed in the making of clear transparent varnishes.

The drying of oils, such as are used in manufacturing paints and varnishes, is a process of slow oxidations and polymerization. This action is accelerated, as is well known, by the addition of siccatives, for example, the salts of lead, manganese, zinc, cobalt, vanadium, cerium and uranium. These substances, which are pseudo-catalytic in nature, can be replaced by the use of ozonized air. Identical results can be obtained therewith and in the opinion of some paint technologists the advantages, due to the use of ozonized oils, are far greater than any that can be obtained in other ways.

A film of paint or varnish dries hard on the exterior within a comparatively short time after it is applied. The interior of the film however remains soft for quite a long time, as the hard exterior coat prevents the access of air to the undried oil and hence delays its oxidation and drying. This is a serious disadvantage in the cases where rapid drying is necessary, and where the painted or varnished articles must be removed from the drying chambers as quickly as possible. It is claimed that when the oil is partially oxidized first by means of ozonized air, the drying of the paint or varnish proceeds rapidly and regularly throughout the entire film, so that a perfect dry coat of paint is obtained.

A particular application of this property of ozonized air is in the finishing of automobile magnetos. In the old method the magnetos, after machining, are impregnated with oil in a vacuum, so that the oil penetrates completely into the interior of each part of the magneto. During the drying operation the surface hardens, while in the interior the oil remains liquid. When the magneto rotates at great speed in its operation, the centrifugal force is often able to throw out the liquid oil and destroy the coatings. It was found that this defect could be remedied completely by ozonization. The oxidation of the oil is accomplished in a mixer by blowing the ozonized air through the oil. Under these conditions the mixture of oil and air is effected in as intimate a manner as possible. At the end of several hours the absorption is sufficient and then the armatures can be dipped in the oil with the certainty that the drying will be complete. In addition to this treatment of the oil, the magnetos are dried in a chamber which is traversed by a current of ozonized air which further assists the drying process. Pianos, varnished with partially oxidized oils, have been dried with ozonized air in drying chambers. The good results that have been obtained in this new process have been very gratifying and have led to its adoption, in preference to the old slow method of drying varnished pianos, in several plants.

Not only may oils be bleached, decolorized and rendered more siccative by treatment with ozonized air, but they may be thickened and even solidified according to the nature of the oil, the conditions under which the treatment takes place and its duration. As far as linseed oil and others of the same type, that is the ordinary drying oils, such as china wood oil, poppy seed oil, rapeseed oil, etc., are concerned, the treatment with ozonized air can first bleach the oil then increase its drying properties, then thicken it and finally cause it to solidify. These actions take place in the order indicated, which is very advantageous, as the oil may be bleached without drying the same.

The operation of solidifying the oil must take place in a mixture provided with mechanical agitators by which the oil is kept in constant vigorous agitation. Otherwise the process is prolonged for an extreme length of time, which renders it absolutely impractical from an industrial standpoint. However, when it is carried out under the proper conditions it is very easy to thicken linseed oil to a syrup or to a jelly for use in the manufacture of linoleum. The temperature at which the process is carried out is of importance. Thus boiled oil thickens very rapidly when the ozonized air is introduced into the oil, kept at a temperature of 65 to 90 degrees Cent. At the end of six to eight hours' treatment, it has solidified into a dark colored product. On the other hand when the process is conducted at a temperature below 40 deg. Cent. the solidification requires 8 to 10 hours, but in this case a bleaching effect is attained as well. The temperature at which the process is accomplished will, accordingly, be determined by the use to which the product will be put. If it is a question of making a light-colored linoleum, then a light colored solidified oil will be desirable and the longer duration process will be used. On the other hand, if a dark colored linoleum is to be made with the oil, then the process of shorter duration may be used.

China wood oil oxidizes rapidly under treatment with

ozonized air, while poppy seed oil and grape seed oil do not thicken as quickly as linseed oil. These oils as well as linseed oil, in their thickened form, are used not only in the manufacture of linoleum but also in the preparation of waterproof materials, fish netting, etc.

In the treatment with ozonized air of hydrocarbons, which are found in petroleum and are obtained by the distillation of coal, lignite, etc., and which belong to the non-saturated series, ozonides have been formed which may then be transformed into fatty acids. In Germany an oil has been obtained from lignite coal, which possesses a brown color and a very disagreeable odor, and boils at 125 to 220 deg. Cent. This oil will give ozonides which are soluble in alkaline solutions. When subjected to the action of steam, the ozonides are converted into peroxides, which react with the alkalies to form a jelly. The oils that are obtained in the distillation of schists can be treated in the same manner.

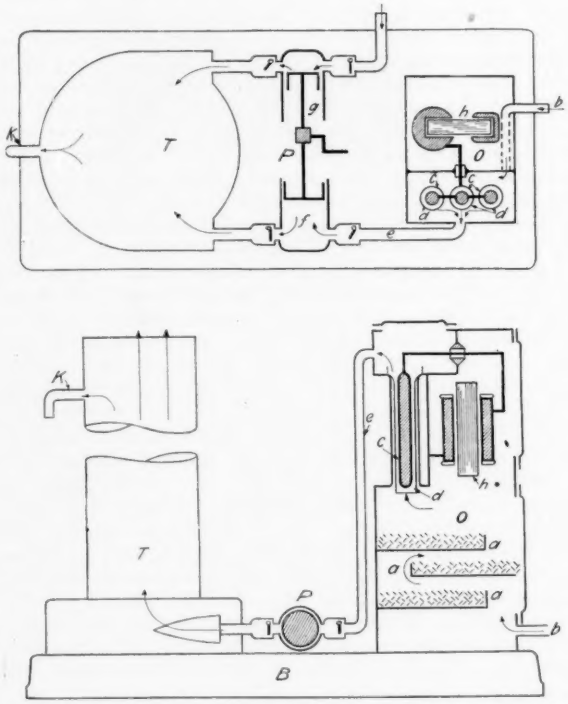


FIG. 6. THE OZONATOR INSTALLED AS A WATER PURIFIER

The process that is used in the Schurstein Ozone Works at Wiesbaden is somewhat as follows: The oils and the alkali solution are placed in tanks of 1200 liters' capacity each, which are cooled with water which courses through a water jacket, and the ozonized air, containing 2 to 5 grams of ozone to the liter of air is bubbled through. A potassium or sodium soap is formed, according to whether caustic potash or soda is used in the process. It has been claimed that from 100 tons of lignite which give 3 tons of tar from which 1.6 tons are obtained after the first refination, which will give 0.64 tons of oil to be treated with the ozonized air, a total of 0.12 ton of crude fat can be obtained.

It has been known for some time that ozone can be used to oxidize organic chemicals and its use in the manufacture of various organic compounds which are made in part or in whole by an oxidation process has been fraught with much success. It has been used successfully in the manufacture of several synthetic perfumes, such as vanillin, heliotrope and anisaldehyde. It has also been proposed to use ozone in the oxidation of aniline to aniline black, and the leuco base indigo to the colored dyestuffs.

In the brewing of beer ozone has found an application not only as a preventive in stopping the growth of foreign micro-organisms during the fermentation process, but also in the refrigeration and bottling processes. Another use of ozone is the preservation of food, especially in connection with refrigeration. Meat must be kept at a low temperature in order to prevent it from spoiling. The use of a low temperature and a sterile atmosphere as well, that is an ozonized atmosphere gives very much better results than cold air alone. Inasmuch as ozonizers are able to work best at low temperatures and as they do not occupy much space it is very practical to use them for this purpose not only in storage refrigerators but in the refrigerating cars as well during the transportation of the meat. Both the internal sources of contamination of the meat, that is the enzymes present therein that cause its decomposition under suitable conditions and the external sources of infection, such as flies and air-borne micro-organisms are destroyed or prevented from acting by the ozonized air and the low temperature.

In the drying of copra, from which we get cocoanut oil, ozone is used to advantage, as it does not give the exceedingly odoriferous product that is obtained in the ordinary sun-drying process. Another interesting use is in the conditioning of flour in flour mills. This is claimed to be attended with an increase in the mill's capacity amounting to possibly 30 per cent and in the practical elimination of the flour moth.

THE MAKING OF EDIBLE FATS FROM PARAFFINE

IT was found that in the oxidation of paraffine at 135 to 145 deg. Cent. the products of the oxidation did not dissolve in soda ash but only in caustic soda. This indicated the presence of fatty substances, not fatty acids, in these products which could be used instead of the ordinary neutral edible fats. Ordinarily it has been found relatively easy to obtain the fatty acids from paraffine by various synthetic processes, but the formation of a neutral fat directly therefrom which could be used as food was not suspected as being possible. The fatty acids are unsuitable for food as such, but can be used in making soap.

The synthesis of fatty acids from paraffine has been accomplished by heating the paraffine under pressure in an autoclave in the presence of suitable catalysts, such as the compounds of the metals, Mn, Pb, Hg, Vd and Cr, and also the alkalies and the alkali earth elements. Then the fatty acid is treated with glycol in the presence of sulphuric acid and a fat is obtained. Such a fat has a cocoanut like odor and when purified is a very good substitute for ordinary fat.

The fat that is obtained directly from paraffine by oxidation does not contain any glycerine. It avoids the necessity of the use of glycol or glycerine in its manufacture. Various tests have been made by private individuals and Government and industrial organizations on the physiological properties of this substance and it has been found that the digestive organs react to it very favorably. It is absorbed into the system through the intestines, and possesses a high food value.

The process of making this product has been patented, but at the present time it has not acquired any great commercial importance. However the principles involved in its manufacture are very interesting and of considerable importance. It is probable that their application to the treatment of the higher fatty acids will result in the production of fats which will possess valuable possibilities of industrial usages as well as food values.—Translated from *Chemiker Zeitung*, 44, 309-310, 477-78.

THE DEVIATION CAUSED BY PAIRS OF PRISMS

IN many optical instruments a variable angle of deviation is obtained by rotating two small-angle prisms in opposite directions about a common axis. In such a system the principal section does not maintain its position for all positions of the two component prisms; in fact, it is only in the case where the inner surfaces of the two prisms are perpendicular to the axis of rotation that one can speak of a principal section of the complete system.

Correspondence

Comment From Our Readers on Articles of Recent Appearance

STALLO AND EINSTEIN

To the Editor of the SCIENTIFIC AMERICAN MONTHLY:

In an editorial in the July issue of the SCIENTIFIC AMERICAN MONTHLY on "Mr. Maxim's Paper of 1889," occurs the following statement:

"In particular, we reprint it at this time chiefly because it contains what we believe to be the earliest unreserved statement of the universal relativity of uniform motion, with no loop hole left for the man who would like to believe that after all there is somewhere something, which, if he could only find it, he could use as a reference frame for absolute motion."

In a volume entitled "Concepts and Theories of Modern Physics" by J. B. Stallo, published in 1881 and 1884 by D. Appleton & Co. in its "International Scientific Series" the nature of motion is thoroughly discussed, and the universal relativity of all motion unreservedly advanced by the author, after reviewing the opinions of men like Neumann, Euler, Leibnitz, Descartes, Newton and Galileo. (See Chapter 12.)

The volume might well have been entitled a treatise on Relativity, for such it really is. It is a critical, although unfavorable, consideration of various theories, physical, chemical, mathematical and astronomical, then commonly entertained. The subjects considered and the conclusions arrived at are well summarized in the following passage:

"There is no absolute material quality, no absolute material substance, no absolute physical unit, no absolutely simple physical entity, no absolute physical constant, no absolute standard, either of quantity or quality, no absolute motion, no absolute rest, no absolute time, no absolute space." . . . "Nor is there an absolute system of coordinates in space to which the positions of bodies and their changes can be referred."—(Chapter 12.)

As a profound and keen thinker, and for scholarly attainments, the author, in my judgment, stands in the front rank.

Prospect, Ohio. EDWARD MAAG.

MAXIM AND EINSTEIN

To the Editor of the SCIENTIFIC AMERICAN MONTHLY:

Hudson Maxim's article of 1889, reprinted in the July MONTHLY, which claims to anticipate Einstein, is a strange mixture of a whole lot of obsolete absolutism, obsolete even at the time he wrote, with a very minute quantity of relativity. It is a curious fact that just a few pages beyond the passage in Herbert Spencer's "First Principles," quoted by Mr. Maxim, occurs a proof of the relativity of motion, that is strikingly similar to Mr. Maxim's. The passage is in part as follows:

"And so we are taught that what we are conscious of is not the real motion of any object, either in its rate or direction; but merely its motion as measured from an assigned position—either the position we ourselves occupy or some other. Yet in this very process of concluding that the motions we perceive are not the real motions, we tacitly assume that there are real motions. . . . we take for granted that there are fixed points in space with respect to which all motions are absolute; and we find it impossible to rid ourselves of this idea. Nevertheless, absolute motion cannot even be imagined, much less known. Motion as taking place apart from those limitations of space which we habitually associate with it, is totally unthinkable. For motion is change of place; but in unlimited space, change of place is inconceivable, because place itself is unconceivable. Place can be conceived only by reference to other places; and in the absence of objects dispersed through space, a place could be conceived only in relation to the limits of space; whence it follows that in unlimited space, place cannot be conceived—all places must be equidistant from boundaries that do not exist. Thus while we are obliged to think that there is an absolute motion, we find absolute motion incomprehensible."

This was first published in 1860. Yet Herbert Spencer did not put forth this theory as new, but merely as one among several illustrations of the relativity of *all* knowledge, which he was advocating. This wider theory, which naturally includes, even if not specifically so stated, the relativity of motion, dates back to the Greek Protagoras. It was the mainspring of the positive philosophy of Compte (1840). Nevertheless, many early writers specifically discussed, and unreservedly supported, the relativity of motion. The illustration of the single body in unlimited space, used by Mr. Maxim, dates back to Euler (1765).

Many of these early writers, however, while arguing for the relativity of *all knowable* motion, still admitted, like Spencer, the possibility of absolute motion. This loophole was thoroughly tamped by J. B. Stallo, "Concepts and Theories of Modern Physics" (1881). He insisted that absolute motion was not only unknowable but nonexistent. He said (p. 200): "The reality of rest and motion, far from presupposing that they are absolute, depends upon their relativity." He went still further and on page 204 stated: "The same considerations which evince the relativity of motion also attest the relativity of its conceptual elements, space and time." Finally, on page 200 he wrote: "In short, the fixity of position of any body in space is possible only on the supposition of the absolute finitude of the universe; and this leads to the theory of the essential curvature of space, and the other theories of modern transcendental geometry." All this sounds much more akin to modern relativity than what Mr. Maxim wrote eight years later.

The fact is that this philosophic relativity, upheld by Maxim and his predecessors, has nothing whatever to do with modern physical or experimental relativity. It is deduced apriori from the nature of conceptional knowledge. No possible experience can either support or shake it. It would stand though all Einstein fell. Physical relativity, on the contrary, is derived from experience. Pure thought could never without experience deduce or predict it.

There are three degrees of physical relativity: Newtonian relativity, special Einstein, and general Einstein.

Newtonian relativity is a consequence of the first two laws of motion, for according to these laws, the mechanical behavior of bodies is unaffected by uniform translation, *relative or absolute*. It is therefore derived from experience. No one could possibly predict, in the absence of experience, that physical motions depend upon differential equations of the second degree, as demanded by these laws. It is much more natural to expect the first degree, as previous notions require. This mechanical relativity obtains whether the philosophical brand does or not. How else could Newton defend absolute motion, while his laws call for relativity?

The special Einstein theory asserts that optical and electrical phenomena are similarly unaffected by uniform translation whether with respect to the ether (so-called absolute motion) or with respect to other bodies (relative motion). Likewise this was not always believed, as witness the Michelson-Morley experiment. But motion with respect to the ether is not absolute in the philosophical sense. It is still the relative motion of two material bodies, therefore theoretically detectable. Experiment alone can show that it is not. But

this ether we are obliged to consider as fixed, because of philosophical relativity. The ether as a whole which means the whole material universe, constitutes an Eulerian single body. Any motion of it would be absolute in the philosophical sense, hence unknowable. Whether such obtains or not is no concern of the physicist. Special Einstein, based on the Michelson experiment, stands, whichever way the decision falls.

The general Einstein theory results from the observation, that the conspicuous mechanical effects accompanying a variation of velocity, can equally be well accounted for by supposing the system on which they occur to be entering a field of force, or more exactly a region where space is distorted by the presence of other bodies. The two hypotheses being indistinguishable, one cannot on the basis of these effects alone, unequivocally assert that his velocity has changed. He must look out and observe the other bodies. The only doubt about the complete validity of this "principle of equivalence," concerned the behavior of light. But the eclipse expeditions showed that the behavior of light is percisely the same as that of mechanical bodies, hence like them gives no unambiguous indication. This relativity then of variable motion is likewise based upon experiment, unforeseeable, undeducible. It is change of motion relative to the rest of the world, not of the world as a whole, that is thus experimentally shown to be indeterminate. It too is therefore independent of philosophical relativity.

Therefore neither Maxim, nor even Stallo, nor any of the innumerable other staunch supporters of the ancient philosophical relativity can be conceived to be in the least precursors of Einstein. If that were not so, I might legitimately claim to be myself such a precursor; for I find in notes written in 1903, discussion of, and unreserved adherence to, the relativity of motion.

M. C. MOTT-SMITH.

Los Angeles, Cal.

THE LEGENDARY ISLANDS OF THE NORTH ATLANTIC

To the Editor of the SCIENTIFIC AMERICAN MONTHLY:

I have been very much interested in reading articles under the above title on the "Legendary Islands of the North Atlantic" by Albert A. Hopkins, in the July issue of the SCIENTIFIC AMERICAN MONTHLY.

It puts me in mind of a lecture which I heard some years ago by Dr. Ronald Strath in Seattle, who had spent some time in Yucatan studying the prehistoric monuments and inscriptions of the Mayas in the jungle. According to Dr. Strath, whose lecture made a vivid impression on me at the time, these inscriptions, which are very voluminous and were then by no means completely translated, gave a complete and very detailed description of the destruction of Atlantis, by a planetoid grazing the surface of the earth, and raising such a heavy cloud that the earth was dark for eighteen months. As I remember it, the date of the catastrophe was also set by astronomical data at about 13,000 years B.C.; and that the earth comes into imminent danger of another similar catastrophe about every 52,000 years.

The inscriptions, if his interpretation of them is correct, give a marvelously complete history of events of the people of Atlantis over a period of several thousand years, together with an account of their social and religious institutions, etc. I was particularly impressed with them by reason of accounts given of struggles over many social problems, such as woman's suffrage, which are supposed to be distinctly modern in character. I also remember an account of a system of suffrage which was worked out, whereby both men and women could vote; but the weight of vote was varied with different individuals of different ages and attainments. Thus an elderly man of experience in affairs exerted more influence than a young man just old enough to vote. There were also many laws, which for simple yet effectve justice in a fairly complicated society, are certainly not equaled in the present day. Their code was evidently the basis for the code of Hammurabi of Babylon, who lived at the time of the scriptural Abraham, and who compiled the earliest hitherto known historic code of laws.

According to Dr. Strath, who I believe had also been in India and Asia as a British Army surgeon, and had made a study of archaeology in those places, the civilization of Atlantis was the parent of the old world civilizations; and the old world nations were founded as colonies of the people of Atlantis. He showed how the architectures of Egypt, Babylon, Ancient Greece, etc., are plainly developments of the architecture of Mayapan, which was the architecture of Atlantis. He showed a photograph of a sphinx in Mayapan very similar to that of Egypt; and told of an account in the inscriptions of Mayapan of the building of the Egyptian sphinx by an exiled queen of Atlantis in memory of her assassinated brother.

He also showed a connection between the Atlantian language and the parents of the civilized languages of the present day, with intent to prove that the Atlantian language, as shown in the inscriptions of Mayapan was the parent language of the modern languages.

I am a layman in the subject at hand, and not in a position to judge of the reliability of Dr. Strath's work. If reliable, it should set at rest forever any question of the authenticity of the Atlantian legends. The inscriptions, illustrated in the lecture, are certainly far too voluminous to have been the result of any hoax. I have also seen other pictures of the same monuments and inscriptions elsewhere. An engineer of my acquaintance has made a number of pleasure trips to Mexico and Central America, and has also obtained a collection of very fine photographs of some of the monuments and inscriptions of Central America. While he obtained them simply as curiosities, and seems to have little idea of their significance, I have no doubt that he could be influenced to publish them, if they would be of interest, without explanation or attempt at interpretation.

Dr. Strath also referred me to a book by Le Plongeon (initials of author and title of book forgotten). I borrowed it but was unable to read this work at the time, though I glanced through it; and made out that in general it seemed to confirm Dr. Strath's conclusions very closely. I have never been able to obtain the book since.

An interesting feature in connection with the account of the destruction of Atlantis by a planetoid, is the fact which I read in a book on geology when a boy, that the geological formation of the diamond fields of Brazil and of Africa can only be accounted for by such a catastrophe as is described in the account of the destruction of Atlantis. Any physicist knows that diamonds are only formed under the intense heat and pressure that such a catastrophe would entail.

It is also interesting to theorise on what would happen to the earth in the event of such a catastrophe and compare that with legendary accounts; the intense heat of collision, though the blow was only a glancing one, would vaporize vast quantities of the water of the Atlantic, which with, clouds of fine ash would be carried in the atmosphere all over the surface of the earth and literally darken the sun. The whole earth would quake and would continue quaking until the maladjustments in the crust brought about by the strain had again become adjusted. Volcanic activity would everywhere tend to increase. On the cooling of the evaporated ocean waters, rains of violence never before or since equaled would cover the earth. There could easily be wide changes brought about in the elevation of lands and the outline of coastal shores. Many things that have puzzled geologists could easily be explained by such a catastrophe. The Sahara desert has never been satisfactorily explained, I believe. It would not take a very large asteroid to accomplish such a result; indeed the collision of one of the larger of them would probably destroy all animal life on the earth, so great would be its disturbances. But it occurs to me that some of our astronomers could furnish information bearing on the matter, by telling us whether there is any known asteroid whose path came close enough to the earth at that time for a collision, and whether there is any-

things in the legend of a 52,000 year periodicity of danger of such a collision with the earth.

If I recall my astronomy correctly, this is approximately the period of the spinning of the earth's axis with relation to the plane of the earth's orbit. It is well known that some of the asteroids have orbits of such eccentricity as to pass close to the earth's orbit. It might well be that one of them would cross the earth's orbit at the time when the earth happened to be close enough to draw it into collision only once in 52,000 years. Certain of the ancients had a wonderful knowledge of astronomy; it is not impossible that they could compute orbits.

I am also inclined to wonder whether the Sargasso Sea—that refuse heap known to mariners of the flotsam of the Atlantic, brought by wind and current from all parts of the ocean, is not responsible for some of the legends of floating islands in the Atlantic. It certainly has an appearance which might easily give the impression of a floating island.

However, this is all speculation. The great pity of it all is that knowledge has reached the point where it takes all of a man's life to obtain a complete knowledge of one subject, let alone sufficient of others to be able to correlate them and obtain really sound conclusions. Scientists used to trace consanguinity of races by lingual similarities, until so many cases of the imposition of the language of one race upon a totally alien race came to light that language was seen to be a totally inadequate basis for their work. But similar conclusions are being drawn from equally inadequate bases in nearly all research work nowadays. The natural sciences, it is true, are beginning to draw together. But the process is but beginning. And we still have the geologist drawing conclusions which a little knowledge of astronomy or of physics shows to be unsound, the biologist working blindly at a problem which a knowledge of chemistry would immediately solve, the Freudian psychologist drawing conclusions utterly at variance with anthropology and history. Not only are research men unacquainted with the work in other sciences, but so many of them are utterly lacking in that quality of sound judgment brought about by contact with human affairs, which is called common sense. So many of them are prone to go mooning about their specialties in utter oblivion to all that is going on in the great and wonderful world around them, and become unbalanced to the point where they are incapable of sound judgment even in their own specialties, however wonderful their detailed knowledge of those specialties may be. I know, for I have several scholars among my immediate friends and relatives and am only too well acquainted at first hand with the narrowness and jealousies of some of them, and how directly it affects their work. My father repeatedly has taken part in faculty meetings of one of our institutions, wherein the curricula of the students are determined. Such meetings become scrambles in which each professor is intent only on seeing how much of his particular specialty he can jam into the curriculum. Nor is this particular institution any marked exception. I have heard of the same thing in one of the foremost universities of the country. [*We have seen it in such a university.*—THE EDITOR.]

What we need in all research and scientific teaching is executives who are not specialists, but who have enough of the knowledge of each specialty to be able to correlate and direct all of the departments to a common end. They should have authority not merely to take haphazard findings and correlate them, but to direct the work for a given end. If, for instance, it is desired to establish the authenticity or non-authenticity of the legends of the lost Atlantis, the work should be in charge of a man of broad education and executive power. He should have authority to direct a geologist, an astronomer, an architect, a linguist, a historian, a specialist in folk-lore—in short a representative of every science remotely bearing on the subject—and get them to dig into the evidence bearing on the subject from all the different angles. With all of their results at hand, he is then in a position to form sane conclusions. There are scarcely two sciences in human knowledge that do not have some facts bearing on each other. None can reach their highest development without the aid of the others. All will in the end be found equally worth while for human advancement.

The organization of research I propose has already been used in the Rockefeller Foundation and other similar institutions with results little short of the marvelous. It is the same organization which is used on every big construction or industrial enterprise. An executive is placed at the head, who has sound judgment, and a sufficient knowledge of all of the processes under his control to be able to direct and coordinate his specialist subordinates and check them against each other. He should have, and usually has, the greater human ability, if I may coin the phrase, while there is probably not one of his subordinates who does not know more about his own individual specialty than the executive does.

Why is it that the process of the advancement and dissemination of human knowledge is a whole age behind every other phase of human activity, and is still largely left to individual initiative, while cooperation is the watchword of nearly every other phase of civilization?

Onekama, Mich. LEO G. HALL.

AN ECHO OF THE EINSTEIN CONTEST

To the Einstein Editor:

Many thanks for the complimentary copy of the book on Einstein's Theories. Outside of the strictly mathematical memoirs on the subject this book gives the clearest and most adequate treatment of the essential features of Relativity that I have seen—and I've glanced over several.

I agree heartily with the judges that Einstein's theory is best presented for laymen in Bolton's essay. Yet I make a mental reservation—as do you—that Murnaghan's contribution is easily first for those who will take the pains to study it. I particularly admire the essayist's nerve in writing for a popular prize competition an article that is of interest and value for adepts as well as for beginners. The long and the short of it seems to be that persons who are too inert to master the rudiments of analytic geometry can form no definite conception of what Einstein has done.

It is too much to hope, I fear, that someone as generous as Mr. Higgins will pay a competent geometer to write a college text-book on the absolute differential calculus. The sale would be limited, but such a book must be available if America is not to sit permanently on the back seat of modern mathematical physics. Such a book should contain scores of drill exercises and should be written so that science and engineering students could read it. Dozens of Americans are competent to write such a text. The material at present is so widely scattered that it is inaccessible to all who are not near a university library. E. T. BELL.

University of Washington.

[*Dr. Murnaghan himself, so he informs us, is at work on a volume which will fill at least part of the field which Dr. Bell justifiably feels to be so vacant. Judging from his Einstein essay, this book ought to be thoroughly good; we shall announce in the* SCIENTIFIC AMERICAN *its publication, giving it a place of sufficient prominence so that nobody who is interested will have any difficulty in finding it.*—THE EDITOR.]

THE DEADLY X-RAY

To the Editor of the SCIENTIFIC AMERICAN MONTHLY:

I have read the paper in the MONTHLY for August giving Contremoulins' thoughts on the fatal power of X-light. The paper is chiefly interesting as illustrating how difficult it is for an independent experimenter to get his results noticed until they are restated by some one within the academic circle, composed of men who work professionally on that special subject. Soon after Roentgen's discovery that some of Lenard's rays would show the bones of the hand, Elihu Thompson

proved by a carefully planned experiment that these X-rays would burn the skin. A statement from so distinguished a man, though not a physician, should have been heeded by the medical profession and proper precautions taken, thus saving many lives. Soon after another experimenter, also outside the academic circle for this particular subject, proved by many experiments on animals, if proper filters were used to strain out the long waves, which he found were the ones producing the effects on the skin, that blindness, sterility, abortion and death could be produced by X-light of shorter waves (without external injury).

Later some of the results were printed in the Boston *Medical and Surgical Journal* for February 14, 1901, to bring them to the attention of physicians. The conclusions that were drawn from these experiments as to the imperative need of protection from X-light had been previously published in the *Electrical Review* for April 11, 1900, and later in the same journal for March 9, 1901; *Boston Medical and Surgical* for January 9, 1902; April 24, 1902; *Electrical Review* for June 14, 1902; April 4, 1903; *Boston Medical and Surgical Journal* for October 1, 1903; and finally in the *Electrical Review* for December 12, 1903 a long list of X-light axioms covering the subject was printed.

What was the result of all this labor for humanity? The papers were wholly disregarded and as a result almost all of the persons using X-light at the time are dead from its effects, while the writer who used the precautions he advised is free from any effects from X-light, though in the experiments he used a generator that produced a light that showed clearly the interior of the body in the cryptoscope used in the examinations, at a distance of 13 meters. Generally this academic neglect of outside work in science is of small importance, as human life is not involved. At the worst it only delays progress. I have a list of many such cases, as early in life I observed this curious phenomenon. One is mentioned as a good illustration. A monk revolutioned biology but the academical biologists took no notice until one of their circle restated the matter many years after.

WILLIAM ROLLINS.

Tamworth, N. H.

VOWEL ANALYSIS

To the Editor of the SCIENTIFIC AMERICAN MONTHLY:

If you will permit me to refer at this late date to Professor Scripture's articles, which you reprint from *Nature* of the 13th and 20th of January, on the "Nature of Vowel Sounds," I should like to emphasize the great service that the writer has done in pointing out that the ordinary methods of Harmonic Analysis are not necessarily adequate for the determination of the composition of a given tone, and may indeed give quite a false representation of the facts, because the sound may have inharmonic components. At the same time, it is doubtful whether his note in a later issue in reply to another correspondent, interpreting some of Professor Miller's results in this field, are justifiable. Professor Miller's curves are evidently harmonic, from the fact that they repeat themselves very faithfully at regular intervals, and establish without much doubt that vowel sounds (and some others) at least *can be* so produced that they are susceptible of harmonic analysis, whether they are always of such nature or not. The fact that Professor Scripture finds the quality of the voice constantly changing in speech is not a matter of surprise, any more than that the human face and form rarely remain exactly the same for two seconds at a time in waking hours; it need not preclude us, however, from seeking to maintain a given quality for a time for purposes of analysis and record, any more than the latter fact prevents us from sitting for portraits.

There is, however, a point in the article that is open to distinct criticism. The writer says, "In the analysis of vowel waves the fundamental is indicated as weak or often almost lacking. We all know that this is the strongest tone of all." It takes all the point out of scientific research if we are going to discard its plain results for what "we all know," especially if the fact of "knowledge" stands on such weak grounds as does the one here referred to. All that we are justified in saying is that a complex note is by common judgment considered as having the pitch of its fundamental; this may happen in cases in which the fundamental is known to be weaker than the upper partial or partials—a fact for which we have the authority of Ohm, Helmholtz and Lord Rayleigh (Theory of Sound, Vol. 1, Sec. 26). When Professor Scripture states that fundamentals are "not of the nature of sine vibrations," he deprives us of any rational definition of the term; we could build up his type of fundamental vibration from a number of sine vibrations of shorter period and thus produce a sound of low pitch from a number of high-pitched ones.

What I believe to be the true interpretation of Professor Scripture's results and those of others in this field, in fact the inescapable conclusion, is that the fundamental is indeed extremely weak in many of the tones produced by the voice and other musical instruments, and that it is further masked in the records by the comparative lack of sensitiveness of the ordinary recording apparatus in the lower ranges. We must then also conclude that there is something in the physiology or psychology of hearing, or both combined, whereby the lowest component of a complex tone, the fundamental, fixes for the hearer the pitch of the whole tone, while the presence or absence of certain upper partials, and their relative strength, determines its quality.

The glottal puff theory is not inconsistent with the harmonic theory. Helmholtz accepted it and stated it very clearly, as seen in the following extract from his Tonempfindungen (Ellis's translation, p. 103); "In order to understand the composition of vowel tones we must in the first place bear in mind that the source of their sound lies in the vocal chords, and that when the voice is heard, these chords act as membranous tongues, and like all tongues produce a series of decidedly discontinuous and sharply separated pulses of air (luftstosse), which, on being represented as a sum of simple vibrations, must consist of a very large number of them, and hence be received by the ear as a very long series of partials belonging to a compound musical tone." There remains to be applied a positive test to determine whether or not Heinholtz was right in concluding that the partials of the voice tones are harmonic.

With reference to another point in the articles, it seems to me to be no more justifiable to say that the difference between the voice of a Caruso and that of a costermonger lies solely in the vocal chords, than it would be to say that the tone of a reed instrument depends only on the reed, without reference to the size, shape, material, etc., of the rest of the instrument, *e.g.*, that the difference between a bassoon and an oboe is only a difference of reeds.

Clark University. PRESTON EDWARDS.

COMPARISON OF STEAM AND ELECTRIC AUXILIARIES

IN *Nautical Gazette* for March 12, 1921, a comparison of first and working costs for the two types of auxiliary machinery on shipboard is given. In the matter of first costs it appears that electrical auxiliaries are about 20 per cent. more expensive than steam except in the case of deck winches, where the difference is 100 per cent. The author, however, considers these differences are largly due to the fact that in many instances full development costs have been charged against the first installations of electrical gear, and with future installations and more complete standardization this excess charge would gradually disappear. Some of the advantages claimed are: (1) Absence of heat in spaces adjacent to the various auxiliaries; (2) elimination of accidents due to freezing and bursting of steam pipes, etc; (3) reduction of vibration and noise, and hence increase of habitability, especially with steering gear; (4) flexibility and simplification of control.

Science and National Progress

Edited by a Committee of the National Research Council

Dr. Vernon Kellogg, Chairman, Dr. R. M. Yerkes, H. E. Howe

TOPOGRAPHIC MAPS: WHAT THEY ARE, WHO USES THEM, AND HOW

By H. P. Little, Secretary, Division of Geology and Geography

The National Research Council is a cooperative organization of the scientific men of America. It is established under the auspices of the National Academy of Sciences and its membership is largely composed of appointed representatives of the major scientific and technical societies of the country. Its purposes are the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.

MANY geologic and geographic facts are adapted to mathematical treatment; the data resulting from such studies can readily be plotted on a map, provided they are related to some definite geographic point. After they have been plotted it is frequently advantageous for purposes of interpretation to connect those having an equal value. The resultant lines usually are given some name of Greek derivation which expresses concisely and accurately the phenomenon with which they are connected; to this word is added the Greek prefix "iso"—meaning equal, and presto, the line through its name interprets itself—if you know your Greek. The following is a concrete example: Every boy who read sea stories knows that when the captain of the good ship Adventure is expecting a storm he keeps a weather eye on the "glass." A meteorologist, though observing the same instrument, would consider he was watching the "barometer." If asked why he used so strange a name he might suitably reply that since the instrument was for measuring atmospheric pressure, and since the Greek "barus" means "pressure," and "metron" a measure, it might be that his term was really a better one than "glass." If the meteorologist kept careful records of the readings of his instrument he might plot the varying pressure on the ship's chart; later he might connect the points of equal pressure by lines and thus he would obtain "isobaric lines" or "isobars" which are just what the word says they are—lines every point on which has the same pressure.

And so it is with many other similar words of the scientist which seem needlessly long to the uninitiated—each one really speaks for itself of the reason for its being. Among a host of such *iso-* words are isonephal lines, connecting points of equal cloudiness; isoseismal lines, connecting points of equally intense earthquake shock; isothermal lines, connecting points of equal temperature; and isobathythermal lines, connecting points of equal temperature at a given depth. Each word says for itself just the meaning given it above.

Such lines, when drawn and carefully studied, often have great practical value. For instance, after the temperatures and atmospheric pressures at numerous selected stations in the United States are plotted on a map, the corresponding isotherms and isobars may be drawn. These lines are the fundamental data of the weather map on which the forecasters of the United States Weather Bureau depend when they make the weather predictions which are published broadcast by the newspapers of the country, read by millions, and heeded by thousands as they direct their ships, watch the grain market, prepare for floods, or make ready to fight the frosts of spring and fall. But this is not a dissertation on weather maps.

Isohypsometric lines are lines connecting points of equal elevation above sea level. They are one of the few *iso-* lines which have a popular synonym. This is *contour* line, a word derived from the Latin through the French and meaning to "turn with," or "encircle"; it tells what the lines do rather than what they are, for a contour often winds in and out among the hills and valleys just as would the ocean if its level should be raised by the pouring in of huge volumes of water through the melting of enormous masses of snow and ice.

A contour line has a real reason for being just as have the isotherm and isobar, and that is to tell the height and shape of the land. The better known methods of representing these features have been by coloring and shading; but neither of these approaches the contour in precision. Those who take the trouble to learn how to use a contour map for these purposes are enthusiastic over its superiority. A few simple rules for the beginner to bear in mind as he studies his map follow: (A map showing the contours of your local region can, if published, be obtained for ten cents from the Director, U. S. Geological Survey, Washington, D. C. The Map Information Office, Department of the Interior, Washington, D. C., will be glad to tell you about government maps available for your section.)

(1) When contours are close together, slopes are steep and vice versa.

(2) When a contour takes the form of a ring, it represents a hill. The greater the number of roughly concentric circles, the greater the height of the hill on a given map.

(3) If successive contours enclose greater and greater areas, the direction of movement is downhill; vice versa, the direction of movement is uphill.

(4) If the bend of a contour is toward higher land, as determined by rule 3 the land marks a valley, at least an incipient one; vice versa, the bend represents a spur or, if inconspicuous, at least a divide between small streams. The nicety of interpretation of the minor bends is a most important factor in determining the details of the land surface from the map. The vertical distance which separates adjoining contours, known as the contour interval, is increased or diminished according to whether the area mapped has great or slight relief and is usually a fixed value for a given map. It is by counting these intervals that the elevation of any point above a known elevation is obtained. To facilitate this calculation every fifth contour is made wider and its height above sea level indicated; further aid is given by stating the exact height in feet at various important points on the map. By these means many maps of the eastern part of the United States allow the elevation above sea level of any point to be obtained within 20 feet; there are comparatively few sections of the entire country, so far as mapped, for which the elevation cannot be obtained within 100 feet.

Before pursuing the subject further the customary distinction between *contour* and *topographic* maps should be made. Contour maps strictly show relief only; topographic maps show relief (*i.e.*, contours) usually in brown, hydrography (*i.e.*, rivers, lakes, canals, etc.) usually in blue, and culture (*i.e.*, the works of man except as they concern the elevation of land and the distribution of water) in black. This is the map which will be our concern for the remainder of the article.

The average person has no conception of the multitude of uses to which the topographic map can be put, or the wide variety of interests to which it makes appeal. There exists at the present time, for the purpose of increasing efficiency

and eliminating duplication, a Government Board of Surveys and Maps, composed of representatives of fourteen Bureaus which use and make maps—predominantly topographic maps. Associated with this Board, at the Board's request, is an Advisory Council to which twenty-two map-making and map-using organizations have elected representatives to serve the public interests. Included are such bodies as the American Automobile Association, American Forestry Association, American Association of Mining and Metallurgical Engineers, American Society of Agricultural Engineers, Appalachian Mountain Club, and the Association of State Geologists, with others equally well known. Surely a numerous and diverse clientele has opportunity to voice its sentiments. The Board and Advisory Council have recently prepared a memorial setting forth the various uses to which topographic maps can be put. Although the list is long, it is sufficiently instructive to merit a summary. Non-Federal uses are grouped as follows: Public utilities, industrial development, highway construction, transportation needs, use of water resources, drainage, agricultural development, development of mineral resources, utilization of timber resources, utilization of grazing resources, educational uses, popular uses, statistical uses, and national defense. Federal uses show the following grouping: The Geologic Survey in its Geologic and Water Resources, Branches and Land Classification Board; the Department of Agriculture in its Forest Service, Bureau of Public Roads, and Bureau of Soils; the Department of the Interior (exclusive of the Geologic Survey) in its Reclamation and National Park Services and the Office of Indian Affairs; the Post Office Department in its Topography Branch; the Federal Power Commission; and the War Department in its Corps of Engineers, Field Artillery, Coast Artillery, and Air Service.

Concrete illustrations of the manner in which topographic maps apply in these varied fields are at hand. In the case of public utilities, a prosperous Connecticut city wished a supply of water, and $10,000 was spent in examining possible sources; later the area was mapped and the City Engineer by inspection only was able to "discover a better supply which the city is now using, and the preliminary survey did not cost the city a cent." In extending the water supply of New York City by the Catskill Aqueduct, topographic maps saved "hundreds of thousands of dollars and years of time. . . ." Industrial uses are many. A business man from the State of Washington wrote that one of the maps was expected to save his company $10,000. The total cost to the Government of making this particular map was $8000. Another company in the same state finds that a course for a transmission line can be laid down from inspection of the map, using data it would take several weeks to compute in the field.

One of the great expenditures in this country in the next few years will be for road improvement. Statements of the value of topographic maps for this work are embarrassing in the richness of their testimony—all should be heard. One says that the value of a complete map of the state would be "worth the cost of completion to the Highway Commission alone. . . ." In another case "we spent two to two and one-half weeks in determining a line of road which could have been determined in ten or fifteen minutes if we had had maps of that area." Again, the "state is very mountainous and the reconnaissance survey for our highways has to be made by inspection of all the country. If topographic maps were available considerable territory could be discarded by a careful study of them." The best route for a railroad may be similarly estimated. From the Cadiz, Ohio, sheet, was projected a new location which affected "a saving of 2,200 feet in distance and 75 degrees of curvature, besides eliminating 600 feet of tunnel." The saving was at least $85,000 through a map costing the Government $4000 to make.

Water resources offer many problems. Estimation of water power is one. The Maine Water Power Commission requested the advice of the Engineering Council and was told that before a final analysis of the state's water power resources could be properly formulated more of the state should be mapped, since the topographic map shows "the extent of the drainage area, the configuration of the land, the fall of streams, the location of reservoir sites, and many other data valuable in the consideration of water power." Similar facts are evidently requisite for the proper reclamation of arid lands. Use of the maps in planning supplies of drinking water has already been described. Closely allied in its problems to getting water is getting *rid* of water. The people of a certain town wanted to drain a pot-hole, but were made to believe that a large lake would run into the ditch. Inspection of a map instantly showed the large lake to be 60 feet lower. Everyone remembers the great Dayton flood of 1913 with its loss of life and its $100,000,000 damages. Plans were at once started to prevent a recurrence of the disaster through the development of storage reservoirs. Probably six months of calculation were saved through the aid of existent topographic maps.

That fundamental industry, agriculture, also profits from topographic maps. The Bureau of Soils shows kinds of soil by a colored overprint. But whether the land is level or rough, on the side of a bluff or in a marsh, is just as important. So it happens that a prospective settler writes to a Commissioner of Agriculture, "I am looking for the best location to secure a homestead by purchase under the U. S. Homestead Law. . . . Any maps showing topography which you can send me will be much appreciated." Whether the land can be drained by ditching will also show, and whether it could be worked by modern machinery. One enterprising mercantile firm gives its farmer customers topographic maps of the local area which they appreciate far more than an almanac or calendar.

Mineral resources, timber resources, grazing resources, statistical uses, national defense, uses by Government Bureaus, educational uses, popular uses—these still remain. Only the last two can be discussed. How do these maps directly affect you and me who are neither engineers, nor capitalists, nor military men? They affect us in many ways. In schools and colleges topographic maps are widely used in courses in physical geography and geology to give the student practice in interpreting the origin of land forms. Usually he cannot go to the famous locality, but the famous locality can be brought to him through the map. Soon the lakes of Maine, the peculiar hills of Boston Harbor, the barrier beaches of Atlantic City, the elongate ridges of the Appalachians, the bayous along the Mississippi, the dunes of Michigan, the gorges of the great plateaus, and the cirques of the Sierras all tell their story.

To the automobile tourist or the humble "hiker," these maps are also of much value. Every bend in the road and every house is located, while contour lines show the grade of the road and the character of the back country. If the region is arid, springs are shown; if humid, every little brook where the fish might lurk. Prospector, hunter, camper, all use the maps.

Yet, strange though it may seem, while the Government has been making specific appropriations for topographic mapping since 1889, only about 43 per cent of continental United States, exclusive of Alaska, has been mapped, and only 35 per cent at all adequately. All of the important European countries are far ahead of the United States in this respect: mapping of most of them has been completed. At the past rate of progress the United States will not complete the task for from 80 to 100 years. Meanwhile, all the various uses above described are impossible of application over much of the country, and the wasteful method of having each interest make its own map must be followed. And this in spite of the fact that a little more than the cost of a single battleship would, as shown in a carefully prepared budget, complete the task in 20 years. There is at present hope that the work will really be done in this time. The Temple Bill, now before a committee of Congress, contemplates just such a program, and the Geologic Survey could find, with the added help of topographers trained during the war, the staff to do the work.

Notes on Science in America

Abstracts of Current Literature

Prepared by Edward Gleason Spaulding, Professor of Philosophy, Princeton University

THE RATE OF GROWTH OF THE DOMESTIC FOWL

In an article in the *Journal of General Physiology* for July 1921, Dr. Samuel Brody of the University of Missouri Agricultural Station presents the results of observations on the rate of growth of the domestic fowl.

If the weight of a mammal, for example the mouse, is plotted against its age, the resulting curve will be seen to show three fairly distinct waves, oscillations, or growth cycles. These waves or cycles are still more strikingly shown by plotting the velocity of growth against the age.

Robertson found that the growth of each of these cycles can be represented by the equation of an autocatalytic monomolecular reaction. This fact, and the theories developed from the fundamental studies on cell growth by Sachs, Morgan, Driesch, Boveri, and Loeb, which were reviewed in a previous paper on the growth of the dairy cow, led Robertson and Ostwald to assume that the limiting factor of growth of each cycle is an autocatalytic monomolecular reaction. Assuming this tricyclic and autocatalytic theory of growth to be true for mammals, it becomes of interest to find out whether the same does not also hold for birds.

One table presented by the author shows the rate of growth of the Rhode Island Red breed of fowl from the time of hatching up to the age of laying. This figure clearly shows the rate of growth to increase from the time of hatching up to about 8.5 weeks of age when the rate of growth is at a maximum; from this maximum at 8.5 weeks the rate of growth decreases to a minimum at about 14 weeks. This is followed by another cycle with a maximum at about 18 weeks of age ending somewhere between 24 and 28 weeks of age when growth of non-fatty tissues probably ceases. That each of these postembryonic cycles follows the equation of an autocatalytic monomolecular reaction can be seen from their shape. Essentially similar results were obtained with other breeds of fowl such as the White Leghorn, single comb White Leghorn, and White Plymouth Rocks, the several breeds differing only with respect to the several constants.

The author concludes that if the tricyclic theory of growth is also true for the bird, then the fowl must go through a complete cycle during its embryonic period of growth.

Summarizing his results, Dr. Brody finds that the growth period of the domestic fowl is analogous to that of the mammal, being composed of three, or perhaps four, cycles; two of these cycles are postembryonic with maxima at about 8 and 18 weeks varying somewhat with the breed and two, or at least one, are embryonic with maxima at 11 to 12 and 15 to 16 days of age. Hatching occurs during the first part of the second or third cycle resembling in this respect the guinea pig rather than the mouse. The velocity curves of each of these cycles are similar to and can be represented by the equation of an autocatalytic monomolecular reaction.

TESTS OF MUSCULAR EFFICIENCY

In an interesting article in *Physiological Reviews* for July, 1921, Mr. E. G. Martin of Stanford University presents the results of investigations on various tests of muscular efficiency, and among them the resistance strength test. This test which differs from other dynamometric tests in that it depends upon overcoming the resistance of the subject rather than upon the exercise of active effort on his part, was developed primarily as an aid in the after-treatment of infantile paralysis and demonstrates its value in that connection. It proved to have certain advantages as a dynamometric test of efficiency and has been utilized in various fields, among which may be mentioned industry (the relation of muscular strength to industrial efficiency), and medicine (in connection with the diagnosis and treatment of "effort syndrome"). Inasmuch as jobs involving manual work nearly always make certain definite demands on the strength of the workers, it is obvious that classification of the workers in accordance with their strength may prove useful. It is true that intelligent employment managers and foremen usually decide on the basis of general observation whether individual candidates are physically equal to the demands of jobs to which it proposed to assign them, but actual strength tests should be useful in supplementing such rough and ready judgments. A more important use for them appears in connection with determining as to whether a man who has been at a certain job for a period is actually measuring up to its requirements. The finding previously referred to that there is a "standard strength" for each job, together with the further observation of Martin that operatives on jobs for which they are physically not suited develop a condition of "staleness" in which they make a strength showing definitely below that of normal healthy adults, offers a means through the strength test of discovering such conditions and rectifying them before injury is done to the operative.

A second industrial application of the strength test is found in the fact that physical condition as indicated by the strength showing tends to bear a definite relation to the industrial efficiency as expressed in output. It appears that external conditions such as temperature, possibly humidity, light, dust-laden air, and other environmental factors, may modify the physical condition as determined by the strength showing. Opportunity is afforded by means of the test to evaluate these factors as well as to form judgments as to the success of remedial measures adopted.

The strength test appears also to have a certain value in connection with estimations of industrial fatigue. Satisfactory criteria of fatigue are so difficult to obtain, that any method which promises to give reliable information on the subject is worth taking into account. The industrial studies of Martin suggest that although the strength showing is not to be looked upon as indicating invariably the presence or absence of fatigue in individuals on single days, it is a fairly reliable index of fatigue of groups or of individuals over a long period, and that where conditions are present which tend to cause entire groups of operatives to experience fatigue, the strength test has utility in their discovery and elimination.

STUDY OF THE RELATION OF THE LENGTH OF KERNEL TO THE YIELD OF CORN

In the *Journal of Agricultural Research* for July, 1921, Mr. C. C. Cunningham presents the results of elaborate experiments to determine the relation of the length of kernel to the yield of corn. Among corn growers there is a prevalent opinion that length or depth of kernel is a very desirable character in corn (*Zea mays indentata*) and that short kernels indicate deterioration. Roughly dented kernels are usually long and, therefore, this type is given preference by most growers in selecting seed corn, while smoothly dented ears are avoided.

Apparently the relation of the length of kernel to the yield of corn has not been investigated directly.

An experimental project was put under way at the Kansas Agricultural Experiment Station in 1916 to secure some data concerning the relation of length of kernel to the yield of corn. Commercial White, a medium large variety well adapted

to growing on productive soils in eastern Kansas, was used. Three 40-ear lots of corn were selected. One lot was made up of ears with kernels that were relatively short, one of ears with kernels of maximum length, and the third of ears with kernels of medium length. The latter group was practically intermediate between the short- and long-kerneled ones. Since the degree of indentation is usually correlated with length of kernels, this character was taken as an index by which to classify the various ears. Only ears that were almost smooth or "dimple-dented" were selected for the short-kerneled group, while only ears that were sufficiently indented to have kernels with a chaffy crown or with at least an indication of chaffiness at the crown were used for the rough- or deep-kerneled group. In this latter group the endosperm as a rule was not completely filled. The kernels of the intermediate group were "wrinkle-dented," that is, the indentation was sufficient to cause a wrinkling of the epidermis of the kernel over the indented portion.

The seed for the various groups or types of ears was continuously selected. Smooth ears were selected each season from the progeny of smooth ears, rough ears from the progeny of rough ears, and medium ears from the progeny of medium ears.

In selecting the seed ears, care was taken to secure, if possible, ears that would conform to what is ordinarily considered the standard in seed corn. The ears were well developed, with uniform kernels and in good seed condition.

Determinations of yield were made in plots consisting of six to eight rows. They were planted in triplicate. The four inside rows only of each plot were harvested for yield. The corn was planted thick in 42-inch drill rows and thinned to a uniform stand of one stalk every 21 inches. No effort was made to control cross pollination between corn of the various types, and undoubtedly the usual amount of cross-fertilization took place.

The author presents his detailed results in fourteen very complete tables covering investigations over a period of five years, and concludes:

The popular opinion that smoothness in corn is an indication of deterioration and reduced yielding capacity appears to be erroneous. In the experiments reported the smooth type yielded as well as the medium and rough types on the average and indicated that under adverse conditions it will yield better.

Continuous selection of smooth and rather short kernels for four generations increased the average length of the ears, decreased the circumference, slightly decreased the weight, decreased the number of rows per ear, and decreased the length of the kernel and the percentage of shelled grain.

On the other hand, continuous selection of rough and rather long kernels decreased the average length of the ear and increased the circumference but had no significant effect on the weight of ears, the number of rows per ear, the length of the kernel, or the percentage of grain.

Because of the popular opinion that smoothness of ears is an indication of deterioration, the results of this study are of practical interest. Smooth corn has several advantages over medium or rough. Every corn grower knows that the smooth type is much to be preferred at husking time. This type is not so subject to damage from molds and other fungi following injury to the ears from the corn earworm. The latter factor is often an important one, since moldy corn is dangerous to feed. Rough ears, because of the length of kernel and circumference of the ears, do not dry out as rapidly as the smooth type, and for this reason they are more likely to be low in vitality as a result of freezing. Smooth kernels are less likely to rot when conditions for germination are unfavorable. It would seem, therefore, that the corn grower should not hesitate to select smooth ears. It may be well to select slightly rougher ears than are desired in the progeny, since there appears to be a decided tendency to vary toward the smooth type. It is also well to do this in order to avoid a hard, flinty type of kernel that would be unsatisfactory for feeding.

RESPIRATION OF DORMANT SEEDS

IN the July (1921) number of the *Botanical Gazette*, Dr. Hope Sherman of the University of Chicago presents the results of the investigation of the respiration of dormant seeds.

Plant physiologists have long been interested in the physiological processes associated with the development and particularly with the germination of seeds. Much attention has been devoted to those seeds which, when ripe, fail to respond to germination conditions unless subjected to special treatment or permitted to undergo a distinct rest period. Such dormant seeds offer many problems to pique the curiosity of the investigator, and work on individual seeds has given some conception of the environmental factors influencing dormancy as well as of the internal conditions retarding germination and of the chemical changes which take place in after-ripening. Furthermore, dormant seeds often retain their viability for long periods of time. Beale reported that *Amaranthus retroflexus* will remain viable in the ground for thirty years. If such seeds are fully imbibed, their remarkably prolonged viability may be due either to especially large food reserves or to a tremendous reduction of the rate at which such reserves are respired.

The seeds selected for investigation by the author were three on which physiological studies had already been made, but for which respiratory data were lacking, namely, *Amaranthus retroflexus*, *Chenopodium album*, and *Crataegus*, and in addition seeds of the common drupaceous *Rosaceae*. Catalase activity was measured by the volume of oxygen set free from hydrogen peroxide.

The author presents many of her results in tabular form, and says in conclusion:

The respiration determinations were made by means of a respirometer. The respiratory intensity, that is, the mg. CO_2 eliminated per gram imbibed seeds per hour, was determined experimentally for *Amaranthus retroflexus*, *Chenopodium album*, and *Rumex crispus*, as well as for *Crataegus* and certain drupaceous *Rosaceae*.

Catalase activity increases in *Crataegus* under after-ripening and germinating conditions (10 deg. Cent.) up to the forty-second day. The slightly higher value for the 128th day may represent: (1) a continued increase at an extremely slow rate; (2) a limit depending on the amount of dioxogen used (5 cc.); (3) a falling off, as a result of secondary dormancy, of an activity whose maximum occurred at the completion of after-ripening (about the nineteenth day). Respiration reaches a maximum intensity much earlier (sixth to eighth day), and thereafter exhibits a slow and fluctuating decline, at least to the seventy-seventh day.

In *Amaranthus* both catalase activity and respiration are relatively stable. Fluctuations in catalase activity and in respiratory intensity do not occur simultaneously, and may be in opposite directions.

The respiratory quotient and respiratory intensity vary markedly for different seeds, and in the *Rosaceae* for different lots of the same kind of seed under precisely similar experimental conditions.

Stability or variability of the quotient may be of significance as indicative of the possibility of an interplay of several factors on the metabolism.

The arrangement of the respiratory quotients for each seed in a curve showing the percentages of the experiments with each seed giving each value, and in frequency histograms in which are plotted the actual number of experiments in which each quotient value occurred, indicates the tendency of each seed toward a typical respiration.

THE MODE OF ACTION OF COLD BATHS IN INCREASING THE OXIDATIVE PROCESSES

IN the *American Journal of Physiology* for July, 1921, Messrs. W. E. Burge and J. M. Leichsenring, of the Physiological Laboratory, University of Illinois, present the results of investigations on the mode of action of low temperatures

and of cold baths in increasing the oxidative processes. Introducing their article, the authors say:

As a result of the work of Lavoisier and of a great number of investigators since his time, it is now known that a fall in the external temperature as well as cold baths increase oxidation in warm-blooded animals and decrease it in cold-blooded animals. The action of cold on the skin of warm-blooded animals produces reflexly an increased innervation of the muscles resulting in movements (shivering) or in the increase in tone. Several observers have shown that unless the lowering of the temperature of the coldness of the bath is sufficient to cause shivering or muscular tension, no increase in oxidation results. Cold-blooded animals, on the other hand, have no heat regulating mechanism such as is found in warm-blooded animals and hence their heat production rises and falls with a rise and fall in external temperature.

The increase in heat production brought about by cold in warm-blooded animals is usually attributed to the additional heat produced by the action of the muscles. Volt believed that the increase in metabolism brought about by cold was due to a reflex stimulation of the muscles resulting in an increase in the inherent power of the muscle cells to metabolize.

The author's experiments were made on 60 warm- and cold-blooded animals. The warm-blooded animals used were dogs and the cold-blooded, turtles. The effect on the blood catalase of keeping these animals in a cold chamber as well as in hot and cold baths, and in baths at different temperatures was tried out.

The cold chamber was constructed large enough to accommodate a dog comfortably. A stream of fresh air was forced through the chamber continuously. Further provision was made for the animal to get fresh air by cutting a small window in the wall of the cold chamber through which the animal could poke its snout. The temperature of this chamber could be kept fairly constant over a period of several hours. Catalase determinations were made of the blood of the jugular before as well as at intervals after the dogs were placed in the chamber. The determinations were made by adding 1 cc. of the jugular blood to 50 cc. of neutral hydrogen peroxide in a bottle and the amount of oxygen liberated in 10 minutes was taken as a measure of the catalase content of the blood. The normal catalase content of the blood was established by making determinations on two or three successive days previous to performing the experiment.

The cold-blooded animals used were turtles (*Pseudemys concinna*). The blood used was taken from the aortic arches through a hole 2 cm. in diameter made in the plastron just over the heart. This hole was kept closed by a cork.

Various experiments are described and their results given by plotting curves.

In conclusion the author finds that low temperatures and cold baths produce an increase in the blood catalase of warm-blooded animals and a decrease in cold-blooded animals, in keeping with the fact that the cold increases oxidation in warm-blooded animals and decreases it in cold-blooded animals. An increase in the external temperature increases the blood catalase in cold-blooded animals in keeping with the fact that it increases the oxidative processes.

The stimulating effect of low temperatures on catalase production in warm-blooded animals decreases with a rise in temperature, disappearing at room temperature (22 deg. Cent.) in keeping with the fact that the stimulating effect of cold on metabolism decreases with a rise in temperature. Baths at 35 deg. Cent. produce no increase in oxidation in warm-blooded animals and it is shown in this paper that such baths do not increase catalase.

The increase in oxidation in warm-blooded animals on exposure to cold is attributed to an increase in catalase, and the decrease in oxidation in cold-blooded animals on exposure to cold, to a decrease in catalase. The increase in oxidation in cold-blooded animals occurring with a rise in external temperature is attributed to an increase in catalase.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

HEAT TREATMENT STUDIES

A REPORT of tests of heat-treated carbon-molybdenum and chromium-molybdenum steels has been completed and will be presented at the September Convention of the American Society for Steel Treating.

I. STEEL CONTAINING 0.20 PER CENT CARBON AND 1 PER CENT MOLYBDENUM

1. For each maximum temperature of heating there is a critical rate of cooling which will lower Ar_1. The higher the initial temperature the slower is the rate of cooling required to produce the lowered transformation but by whatever combination this is produced the position of the "low point" is fixed within a narrow temperature range about 525 deg. Cent. (975 deg. Fahr.). Its suppression can readily be brought about, however, by increasing the rate of cooling.

2. A high temperature transformation is observed slightly above and almost merging with Ar_2 when the steel is cooled from temperatures at or above 960 deg. Cent. (1760 deg. Fahr.) at a rate of temperature change approximating 0.15 deg. Cent. (0.27 deg. Fahr.) per second but is not observed when cooling at a much faster rate.

3. Ar_2 is fixed at about 760 deg. Cent. (1400 deg. Fahr.) independent of the maximum temperature of heating or rate at which the steel is cooled.

4. The most suitable temperature from which to harden the steel is in the neighborhood of 910 deg. Cent. (1670 deg. Fahr.). Free ferrite is found after quenching from 830 deg. Cent. (1525 deg. Fahr.) but the observed changes in mechanical properties with rise in quenching temperature within this range cannot be explained by known changes in carbon or iron, by differences in the rate at which the steel passes through the critical ranges resulting from changes in initial temperature of cooling, by unsatisfactory hardening or by the lowered Ar_3 transformation (except as related to a molybdenum change), for they are opposite to the changes found in plain carbon steel under similar conditions of treatment.

5. For the production of definite tensile strength, water quenching is to be preferred on account of the higher proportional limit, ductility, and impact values obtained and conversely better tensile properties are obtained for a given impact resistance.

6. Raising the quenching temperature from 910 deg. Cent. (1670 deg. Fahr.) to 980 deg. Cent. (1795 deg. Fahr.) does not materially alter the mechanical properties of the steel when subsequently tempered at the relatively high temperature 540 deg. Cent. (1000 deg. Fahr.).

II. STEEL CONTAINING 0.27 PER CENT CARBON, 0.9 PER CENT CHROMIUM AND 0.5 PER CENT MOLYBDENUM

7. The Ar_1 transformation is first split and lowered when cooling from 960 to 1000 deg. Cent. (1760 to 1830 deg. Fahr.)

at about 0.15 deg. Cent. (0.27 deg. Fahr.) per second, the "low" point being observed at about 480 deg. Cent. (895 deg. Fahr.). In water quenching from the highest temperature, a lower hardness is obtained than when similarly cooling from 960 deg. Cent. (1760 deg. Fahr.). In this respect the chromium-molybdenum steel behaves similarly to steel containing 0.20 per cent carbon and 1 per cent molybdenum except that the observed changes are produced from higher temperatures.

8. In normalizing the chromium-molybdenum steel, a low limit of proportionality and impact resistance are obtained when using temperatures between about 780 to 845 deg. Cent. (1450 to 1550 deg. Fahr.).

9. The fact that no material changes in tensile or impact properties are produced by oil quenching the chromium-molybdenum steel from a wide range of temperatures when subsequently tempered at 540 deg. Cent. (1000 deg. Fahr.) has been confirmed. To produce high impact values in the hardened steel, a tempering temperature in the neighborhood of 650 deg. Cent. (1200 deg. Fahr.) is required.

EXPERIMENTAL PAPER MILL BEING SENT TO SIAM

SIAM will soon have an experimental paper mill made in America with equipment recommended by the Bureau of Standards. This paper-making plant, which, although not primarily intended for commercial purposes, will furnish the writing and printing paper for the Siamese army, is now being carried across the ocean to this Asiatic country.

The mill is complete in every detail and spare parts and supplies are included in the shipment. It is patterned after the experimental mill located at the Bureau of Standards which has been in operation since 1913, and was made by representative manufacturers of paper mill machinery in this country. The mill being sent to Siam is about 50 per cent larger than the one at the Bureau, and is capable of producing 1200 pounds of paper daily.

Siam is interested in paper-making because of the possibilities of turning some of her grasses, weeds, and other fibrous plant products into paper. The paper mill will be used in making researches which will aid in the development of a Siamese paper industry.

Bureau of Standards' tests have shown that rice straw, banana tree stems, and lalang grass will make paper. These materials were sent to the Bureau from Siam and were made into paper in the mill. Siamese experiments will be made to develop the best methods of using jawa weed and other plants of that country as well as waste paper.

America is also sending to Siam with the mill a trained paper maker and engineer who will superintend the erection and operation of the mill.

The interest of the former Siamese Minister, Probha Karavongse, in the experimental mill located at this Bureau led to the purchase of the paper-making machine which will be erected at Bangkok, Siam, under the supervision of the Royal Survey Department of the Siamese army. Siamese officials saw the possibilities of the paper industry in their country and their government asked the American Government, through the State Department and the Department of Commerce, to supervise the design and purchase of the experimental machine.

The paper mill consists essentially of a 44-inch Fourdrinier paper machine; two 300-pound wood-tube beaters; a small Jordan engine; a 600-pound rotary boiler; a cylinder duster; screen; sheet cutter; suitable pumps, shafting, pulleys, and motors; a bleach plant; necessary electrical fittings, and plumbing, belting, and spare parts.

COLORLESS WATERPROOFING MATERIALS

A PRELIMINARY report of exposure tests on specimens of stone treated with these materials is being issued and will be available for distribution during September. This report shows the effects of 6 months' exposure to the weather on the waterproofing value of 19 different treatments. It also shows the effect of the appearance when applied to light colored stones.

Copies of this report may be secured by persons interested in this subject by addressing the Bureau of Standards, Washington, D. C.

FOREIGN SPECIFICATIONS FOR PORTLAND CEMENT

THE Bureau has recently completed a summary of the Portland cement specifications of various countries. This included not only the principal requirements but also many of the details of methods of tests, which details are frequently of great importance when considering the specifications of some of the countries. However, for ready reference, the principal physical and chemical requirements have been assembled in a single chart 16 x 22 inches, and copies may be obtained by persons interested by addressing the Bureau of Standards, Washington, D. C.

TENSILE PROPERTIES OF STEELS AT HIGH TEMPERATURES

THE report of tests of alloy steels at elevated temperatures completed last month has been accepted for Bureau and outside publication under the title "Tensile Properties of Some Structural Alloy Steels at High Temperatures" and will be presented at the September Convention of the American Society for Steel Treating.

Four steels containing about 0.40 per cent carbon were tested at various temperatures between 20 and 550 deg. Cent. The type compositions follow: (a) Plain carbon steel; (b) 3½ per cent nickel steel; (c) steel containing 3 per cent nickel and 1 per cent chromium; (d) steel containing 1 per cent chromium and 0.2 per cent vanadium.

Of the four steels tested it appears that the two alloys containing chromium show greater resistance to weakening by increase in temperature to about 550 deg. Cent. than either the plain carbon or 3½ per cent nickel steels, and at this high temperature the chromium vanadium steel is to be preferred from the standpoint of high tensile strength and limit of proportionality.

The carbon and 3½ per cent nickel steels behave alike with rise in temperature above that of the room and at about 550 deg. Cent. the addition of 3½ per cent of nickel appears to have little or no effect on the tensile properties of the carbon steel.

Reference is made in the report to the type of fractures obtained in testing steels at various temperatures and typical microphotographs are included.

CALCIUM SILICIDE

THE use of calcium silicide was recently discussed by *The Iron Monger* as a deoxidizer particularly in steel making in electric furnaces. The compound is now being made on a commercial scale in France and is somewhat similar to ferro silicon. When added to the molten metal the compound dissociates so that the elements combine first with the oxygen present in the bath and then recombine as calcium silicate which appears in the slag. The reaction is so vigorous that sufficient energy is liberated when the silicide decomposes to raise the temperature of the bath of metal. The compound, therefore is valuable in assisting to bring cold baths to the proper pouring temperature. Under the conditions obtaining in the electric furnace the system has also been found to act as a desulphurizer. No harmful inclusions in the metal are left behind and great soundness is claimed for the castings. Calcium silicide is usually added to the bath in small quantities in paper bags which are completely buried in the ladle of metal. From 10 to 20 ounces of the compound per ton of metal are used where the carbon is not more than 0.3 per cent. Where the carbon is above that figure about 30 ounces per ton have been found necessary.

Calcium silicide is hard, bright, and metallic and is easily reduced to powder.

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

SOME RECENT FOREIGN POWER PLANTS

THE *Elektrotechnik und Maschinenbau* for June 5 and 12, 1921, describes the Zillingsdorf power plant located at a distance of about 80 km. from Vienna in a district rich in lignite deposits. The caloric heat of this lignite varies from 2034 to 3200 metric heat units per kilogram. Most of this lignite appears on the surface and is mined by means of dredges. The present equipment of the power plant consists of eight high power steam boilers, each having 500 sq. m. of heating surface; two 8000-hp. and two 12,000-hp. turbo generators giving three-phase energy of about 5000 to 5500 volts. The boilers were equipped with a firing system suitable for burning this low-grade brown coal; very large grates and a deep fire and an automatic staircase-grate were necessary. The plant, according to tests, has a boiler efficiency of 77.1 per cent.

The 38-km. transmission line consists of two 70,000-volt, three-phase lines of 50 sq. mm. copper strands. These are supported on steel towers spaced 150 m. apart in the open and 60 m. near inhabited places. A steel cable fastened to the top of the poles acts as a lightning arrester. Four-disk and five-disk insulator chains are used. Inductive interference is avoided by having the lines transposed twelve times; the telephone wires are carried on separate poles, following a different route. During the year of 1920 energy amounting to over 60,000,000 kw-hr. was transmitted to Vienna, which helped very materially to overcome the coal shortage.

Another interesting plant is that of the Tata Hydroelectric Supply Company in India. A detailed description of it will be found in the *Siemens Zeitschrift* for April, 1921 and an abstract in *Electrical World* for August 27, 1921. To utilize the large amount of annual precipitation during the wet season three large artificial lakes have been made on the west coast of India about 520 m. above the sea level. A total of 300,000,000 cu. m. of water may be accumulated in these lakes during a period of three to three and one-half months. From the water-collecting tower two riveted steel pipe lines of 2 m. diameter each lead down 2700 m., splitting up from this point into five lines of 0.8 m. each. The entire right-of-way for the pipes has been blasted out of the solid rock of the slope. At present five main turbines of the Pelton bucket-wheel type are installed, each rated at 13,750 hp. and operating under a pressure of 50 atmospheres and 300 r.p.m. Each turbine is coupled to a 10,000 kva., 50-cycle generator delivering 6000-v. three-phase current. The power house has room for three more units. The high average air temperature of 45° C. called for great liberality in designing the generators. In fact, the machines as built would be sufficient for 16,000 kva. in northern climate. In spite of the climate the generators show an efficiency of 95.8 per cent.

AIR-INSULATED TRANSFORMERS FOR VERY HIGH VOLTAGE

IN designing testing transformers for very high voltage—200 kv. and more—it is considered a matter of course to choose the oil-insulated type. Although oil makes it possible to cut down the necessary distance between the coils to one-third of the necessary distance in air, it has been proved that after the first brush discharge under oil the high initial dielectric strength of the oil is rapidly decreased along the path of discharge, leading soon to a breakdown. The author points out further that a reliable lead construction through the metallic cover of the oil tank of the transformer is almost impossible for more than about 300 kv. A Swiss firm (Haefely) investigated the possibilities of air-insulated dry-type testing transformers and developed a new model of this type, a 200-kva., 300-kv. testing transformer, which gives good results in daily service in the firm's testing laboratory. The necessary striking and creeping distances have been obtained by properly dimensioned air spaces, the use of paper cylinders and a careful distribution of the electrostatic stress by means of metallic shields over and near the end turns. In spite of the large outfit and very high potential (300 kv.) the finished transformer weighs only 4½ tons, or 70 per cent less than an equivalent oil-type machine. Even with a 25 per cent overvoltage it is claimed no discharges are visible if the machine is fully excited in the dark. The winding of the transformer is of the concentric style, and the high voltage is grounded in the middle (at the end of each of the two coil stacks). By using one or more additional transformers in series with the main transformer as much as 500 kv. against ground may be obtained safely. Such a tandem group is in use at the testing laboratories in Zurich for 400 kv. The author is of the opinion that the design of high-voltage power transformers should not meet with great difficulties.—Dr. W. Hess, *Bulletin de la Association Swisse des Electriciens*, May, 1921. *Electrical World*, August 27, 1921.

ELECTRICAL RESISTANCE AND INSTRUMENTS BASED ON THE TEMPERATURE-VARIATION OF RESISTANCE

A DISCUSSION on this subject was recently held by the Physical Society of London, which discussion was reported at considerable length in their *Proceedings* for April 15, 1921. It discloses a great number of scientific measuring devices based on the variation of electrical resistance and clearly shows the ever-increasing field of their usefulness in science and industry.

The discussion was opened by Prof. Richard Glazebrook who presented a paper in which he gave a historical account of the absolute determination of the unit of electrical resistance. This was followed by a paper by F. E. Smith who made the following two proposals: (a) All resistances should be expressed in ohms (10^9 cm./sec.), without qualification, such as legal, international, etc. The ampere and volt should be similarly treated. (b) Resistance should be more often measured in terms of the C.G.S. units by means of the rotating coil method.

Several authors then presented papers reviewing the recent progress made in resistance thermometry. Prof. H. L. Callendar briefly reviewed the theory and uses of calorimetric thermometers, compound thermometers for linear scale, compensation of thermometers for conduction along the leads, compensated bolometer and the radiobalance. Mr. C. R. Darling reviewed the early work on the resistance pyrometer, Mr. C. Jakeman described the resistance thermometers for steam temperatures. These are used in connection with experiments upon the properties of steam under pressure; they are platinum resistance thermometers with envelopes of steel tube arranged so that the metal envelope could be screwed into a special fitting in the steam pipe. Mr. Edgar A. Griffith gave a detailed description of an electric transmitting radiator thermometer. It is of interest as it is commonly supposed that resistance thermometers find no application on the modern airplane. The outfit described was captured during the war and formed part of the equipment of a bombing machine. It was used for measuring the temperature of the water in the engine

radiators, and two pyrometers were connected to one indicator fixed on the instrument board.

The *hot wire microphone* was discussed by Major W. S. Tucker. Details of this instrument were given in a paper on "The Selective Hot-wire Microphone," read before the Royal Society on January 20 of this year. In his paper Major Tucker primarily discusses experiments illustrating the function of convection currents in determining the sensitivity of the hot-wire microphone.

Considerable attention was also given to hot wire anemometry. The latest development along this line was given by J. S. G. Thomas in a paper entitled "Directional Hot-wire Anemometer." According to the author, the laws of convection of heat from fine heated wires are such as to indicate the hot-wire type of anemometer as the proper type of instrument for the precise measurement of the velocity of a slow moving stream of fluid. The usual type of the hot-wire instrument, as devised by King and Morris, is not suitable in such a case, owing to the disturbing influence upon the convection current arising from the heated wire exposed to the cooling action of the stream. In the directional type of instrument, two fine platinum wires are mounted parallel, and one behind the other in close juxtaposition, transversely to the direction of flow of the gas in the pipe or channel. The wires are inserted in a Wheatstone bridge in the usual manner, and the indications of the instrument enable both the magnitude and direction of a slow-moving stream of fluid to be readily ascertained. For further details the author refers to a number of papers previously published by him. Along the same line was the paper presented by Alfred H. Davis and entitled "An Instrument for Use in Measuring Convected Heat." The apparatus consists essentially of a Wheatstone's net and is a null instrument.

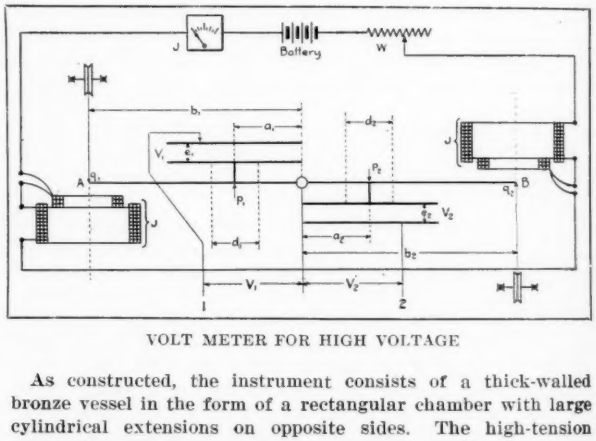
The *catharometer* and its many applications to the measurement of the composition of industrial gases were discussed by Messrs. G. A. Shakespear and H. A. Daynes. A brief description of it will also be found in an earlier issue of the SCIENTIFIC AMERICAN MONTHLY. The *calcometer* is an instrument designed by Prof. Leonard Hill; it measures the heat loss of a wire coil maintained at a constant temperature. It enables the meteorologist or hygienist to record daily variations of the rate of cooling of a surface at body temperature produced by atmospheric conditions. The records taken out of doors thus obtained throw light on the causation of those feelings which lead us to define the weather as pleasant, unpleasant, bracing, muggy, etc. Records taken indoors enable one to measure the cooling power of the atmosphere on a surface at body temperature and guide one to the securing of adequate ventilation.

Finally, Edgar A. Griffith described the liquid depth gage. It is based on the well-known fact that the cooling power of a liquid is vastly greater than that of a gas. It consists essentially of a thin wire of platinum electrically heated to a temperature excess of about 20 degrees above the surrounding air. The wire is insulated and suitably protected by a tube projecting to the full depth of the tank. The portion of the wire immersed in the liquid is cooled down to practically the same temperature as the liquid, while the part above the surface is at the excess temperature. It is evident that the average temperature and hence the resistance of the wire, will depend upon its depth of immersion in the liquid. The changes in resistance are then measured by a Wheatstone bridge arrangement.

AN ABSOLUTE VOLTMETER FOR 250,000 VOLTS EFFECTIVE

THE instrument described is an absolute electrostatic voltmeter for use in calibrating high-pressure voltmeters. Nitrogen at 12 atmospheres is used for insulation, its breakdown pressure at 10 atmospheres being 240 kv. per cm. (according to Petersen), *i.e.*, more than twice that of the best transformer oil. Other advantages of nitrogen in this application are: (1) The insulation is not deteriorated by a flash-over, but is improved. (2) The dielectric constant is nearly 1.0. (3) There being no oxygen present, no ozone is formed, and there is no burning at the point of sparking. (4) Oil would damp the moving system excessively.

The arrangement employed is shown diagrammatically in the figure. The instrument consists of a double voltage-current balance, the beam AOB of which is pivoted at O. The balance is symmetrical about O, components to the left and right being distinguished by suffixes 1, 2, respectively. At distances A_1 A_2 from O there are fixed to the beam pressure plates of diameters d_1 d_2. These are surrounded by guard rings which lie in the same plane as the movable voltage plates and are connected electrically therewith. Fixed voltage plates are mounted at a distance e_1 e_2 from the movable plates. The potential difference V_1 V_2 is applied between the fixed and movable plates. At distances b_1 b_2 from O the beam carries movable current coils which dip into larger fixed coils as shown. The four current coils are traversed in series by the same current J. The torque applied to the beam by the movable voltage plates is proportional to the square of the applied voltage. Similarly the torque applied by the current coils is proportional to J^2, hence when the beam is balanced V is proportional to the compensation current J. A moving coil ammeter measuring J may be calibrated to read directly in volts, the instrument giving the effective value of applied voltage independent of frequency and wave form.



VOLT METER FOR HIGH VOLTAGE

As constructed, the instrument consists of a thick-walled bronze vessel in the form of a rectangular chamber with large cylindrical extensions on opposite sides. The high-tension connections are carried through corrugated cylindrical insulators in the tubular extensions to the balance, which is mounted in the rectangular chamber across the length of the instrument. The casing is tested to an internal pressure of 20 atmospheres. The leading insulators are hollow and are so perforated that they are exposed internally as well as externally to the compressed gas. The spacing between the leading-in bolt and the flange holding the insulator in the casing is such that flash-over would occur at this point rather than from the delicate voltage plate of the instrument. Equilibrum of the balance is determined by observing a mirror in the instrument through a telescope.

It is impossible to determine the accuracy of the instrument by direct comparison with a standard instrument. The author, therefore, considers individually the possible sources of error and their magnitude. The sources of errors are as follows: (1) Stray electric and magnetic fields. (2) Temperature effects and mechanical expansion of the instrument chamber. (3) Inequality of corresponding right and left dimensions. (4) Errors in determination of the individual quantities and dimensions in the equation or law of the instrument. The author investigates each of these groups of possible errors in considerable detail. The highest possible error due to errors in the values accepted for the dielectric constant of nitrogen, the balance weight, and the linear dimensions of the instrument is considered to be ± 0.187 per cent. Allowing also for errors in current measurement and for

errors in balancing, the total error is from 0.6 to 1.0 per cent at 50 or 100 kilovolts (parallel or series connection) and about 0.35 per cent at 150 or 300 kilovolts. The capacity of the instrument in series connection is about 10 cm.; hence, high-frequency measurements may be made. The instrument has been used up to 300 kv., and the author considers that similar instruments could be built for much higher voltages.—A. Palm. Abstracted in *Science Abstracts*, Section B, May, 1921, from *Zeits. Techn. Physik.*

ELECTRIFICATION PROGRAM OF CZECHOSLOVAKIA

PROF. FERNANDO PIETSCH gives in *Electrical World* for August 20, 1921, a detailed account of the present and planned developments in the new Czechoslovak Republic.

As far as a geological survey could ascertain the republic has within its boundaries total resources of anthracite, bituminous and lower grade coal amounting to about 140,000,000,000 tons. According to official statistics for the year 1920, the coal production was: Anthracite, 5,565,000 tons; coke, 700,000 tons, briquets, 722,000 tons; and bituminous coal, 9,800,000 tons.

The maximum output of the hydroelectric power plants, either already available or soon to be developed, is as follows: In Bohemia, 355,000 kw.; in Slovakia, 200,000 kw.; and in Moravia, 59,000 kw.; this gives a total of over 600,000 kw. for the entire republic. Statistics for 1919 showed 390 power plants in the republic, of which there were six rated at more than 10,000 kw., three from 5000 to 10,000 kw., and twenty-eight from 1000 kw. to 5000 kw.

The new electrification law which passed on July 22, 1919, provides for a general and systematic power supply of the entire republic. A first appropriation of 75,000,000 crowns has been made and will be used for the enlargement of hydroelectric plants and for the assistance of such associations as will be a part of the new system. Financial participation of counties and joint stock companies in this public service system has been limited to a maximum of 25 per cent. All plants which will participate in the general electrification plan have been classified as public utilities and will enjoy certain rights.

Of great importance is the establishment of a consulting board for the entire system, consisting of representatives of industry, agriculture, science, labor and consumers of energy. All plans for new developments have to be presented to this board for approval. This board has established a number of standards for the systematic carrying out of the work, the most important of which are: Steam power plants should be erected only on a large scale and if possible near mines. Hydroelectric plants should be operated to maximum economy along the whole river and should be built with a view to cooperation with other nearby plants. All transmission lines should be so built as to form a uniform network. All energy generated should be three-phase at 50 cycles. Railway power stations and enterprises which can prove that such energy will not fill their requirements are excepted. For the standard feeder voltage of 22,000 volts has been decided upon, except for nearby power supply for which the direct generator voltage is sufficient. For the standard trunk-line voltage of 100,000 volts has been chosen, with the permission to use temporarily 50,000 volts. The consumers' voltage should be 220-380 volts. For private enterprises 500 volts with grounded neutral is permissible. In direct-current distribution systems 440 volts with grounded neutral should be provided. As standard generator voltage 6000 volts has been established.

The goal of the whole program is to supply all needed electrical and mechanical energy from this systematized network into which nine large steam power plants will feed. Besides these all hydroelectric plants which operate by means of water storage are to be tied in and to cover all peak loads in order to save coal. Assuming this hydroelectric energy to amount to 500,000 kw., a yearly saving of about 6,000,000 tons of coal will result. For all new steam power plants gasification of coal on a large scale is recommended, so as to obtain all the valuable by-products such as tar, ammonia, etc.

The cost of the new steam power stations and lines is estimated at about 1,500,000,000 crowns. These stations and the network should be completed in twenty years, while about fifty years is allowed for the completion of the hydroelectric developments.

The use of electrical energy could be increased very materially by electrifying the principal railroads, but present conditions are not promising for this, and it is found far more profitable to sell the energy for industrial purposes. The railroad department is, however, investigating a main road electrification within 50 km. of Prague which would relieve the present very congested conditions.

ELECTRICAL EQUIPMENT OF GYRO STABILIZERS FOR SHIPS

THE *Electric Journal* for August, 1921, has several papers giving in detail the design and installation of the electrically equipped gyroscopic stabilizer on the steam yacht "Lyndonia."

Alexander E. Schein discusses the laws and nature of the rolling of a ship; he then reviews the development of the gyro stabilizer. The passive type was invented by Dr. Schlick. It was called "passive" because it was not effective until the roll of the ship was large enough to "precess" the gyro. It, therefore, could not decrease all of the roll due to its sluggishness. The active type stabilizer was invented by Mr. Elmer A. Sperry of New York and was a very great improvement over the passive type in that it introduced ingenious controls which enable the stabilizer to become operative a fraction of a second after roll started, and the result is that roll can be decreased to very small angles. The author then proceeds with briefly reviewing the theory of the gyroscope and of the methods of design of the "Lyndonia" equipment.

The details of the actual construction are given in a paper by Mr. W. T. Manning, while T. P. Kirkpatrick and H. C. Coleman present the details of the electrical equipment. The principal operations of stabilizing a vessel are controlled by two motors, the spinning motor and the precession motor. The spinning motor, as its name implies, keeps the rotor spinning about its axis, which is normally vertical. The precession motor, operating through a worm gear, precesses the stabilizer at intervals corresponding to those of the waves. The combination of these two rotation sets up a gyroscopic couple at right angles to both of them. This couple, transmitted through the gudgeon bearings to the ship structure, counteracts the efforts of the waves to make the ship roll. The complete electrical equipment required by the stabilizer consists of the following. (1) Control gyro; (2) precession motor; (3) generator to supply power to precession motor; (4) magnetic brakes for precession system; (5) motor-driven vacuum pump; (6) control panels; (7) spinning motor; (8) generator to supply power to spinning motor. In this paper special attention is given to the precession system and the spinning motor.

Of special interest is an editorial in the same issue of *Electric Journal* written by E. A. Sperry. According to the inventor of the stabilizer the popular conception of stabilizing a great transatlantic liner is entirely erroneous. There is inevitably pictured a titanic contest of the great rolling mass of the ship in the grip of something potentially as gigantic, struggling to subdue part of its motion. This conception also affords an explanation of the enormous stresses that are supposed to be involved in the process. Now, this is not at all true; it is much easier and simpler. We do not reduce the roll, we suppress it utterly by dealing only with beginnings. All rolling of ships is a gradual accumulation of individual wave increments. The slight extent to which any single wave rolls the ship is now well understood, and all that is required is a comparatively small gyroscope that is capable of completely quenching this single increment.

A little gyro feeler or "control gyro" detects the incipient roll at its beginning and also shows its direction. This is the

crux of the whole cycle; the rest is easy. Through a relay and motor the large gyro is artificially precessed and delivers stresses of opposite sign to the ship.

To anticipate, however, one must apply the counter moments simultaneously to their being received from the sea. This would be impossible were it not for the slow period of the ship itself, which gives an abundance of time to get precession under way and deliver the counter stresses within the half period, continuing until the ship has actually been given a counter incipient roll, whereupon the electric contact in the control gyro is broken, indicating that that particular wave has been fully countered, meanwhile the ship, having received equal stresses of opposite sign, never starts to roll. This process involves not only a relatively small apparatus, but entails merely a trifling stress in the hull, that due to a single wave increment only, involving stresses of from one-sixth to one-tenth those present in a rolling ship.

The disappearance of roll is accompanied by a most satisfactory suppression of pitch. On most headings more than sixty per cent of the pitch disappears with the roll. An astonishing difference in headway also exists between a stabilized and unstabilized ship, repeated records showing between ten and twelve per cent. The importance of such a substantial gain cannot be neglected. It has been found through work done last autumn by Commander McEntee at the Naval Basin and other correlated results since obtained that the stabilizer will make a saving of upward of thirty per cent in heavy weather.

The gyro stabilizer seems to be fitted by nature to deal with large ships. The stabilizing strength varies as the sixth power of the size. For example, a gyro twice the size of another would have to rotate at only one-half the speed of the smaller one to stabilize a ship 64 times the size, *i.e.*, 64 times the total periodic mass can be handled at a cost and weight of less than nine times.

The gyro causes pounds easily to deliver tons of useful torque. Not only does it relieve the ship of all major stresses and increase its life, but it imparts marvelous comfort to the passenger carrier. Stabilizing also prevents the serious depletion of cattle and horses in live stock ships. Through a variety of other important economies to which it directly contributes, it constitutes a definite dividend payer of large magnitude, paying for itself in a comparatively few trips.

MAGNETIC PROPERTIES OF COMPRESSED POWDERED IRON

THE development of a successful method of compressing insulated grains of iron to produce a material magnetically and electrically suited for use in the telephone plant has had a determining effect upon recent progress in methods of loading and compositing telephone lines as well as upon the introduction of carrier systems of multiple telephony. The most important use of this material is in the construction of cores of the loading coils which are introduced at regular intervals to increase the inductance of a telephone circuit. It is also used in the cores of inductance elements in filters for carrying current systems and in those of reactance coils and transformers for radio telephone circuits. The requirements which are to be met involve a core material which should have a constant permeability, a small hysteresis loss and a small eddy current loss within the range of magnitizing forces and frequencies which are met in a telephonic operation.

These requirements were met successfully in the early development of loading coils by the use of hard iron, preferably in wire form. It was found necessary to have this wire drawn to a diameter of 0.004 in, and, in addition, to insulate the separate convolutions of the contiguously-wound core. Cores constructed in the above manner were used for a number of years. With the introduction of repeaters, and especially on composited and phantomed circuits, the requirements as to stability and constancy in the physical characteristics and operation of loading become more severe. To meet these conditions it was found necessary to introduce air gaps at right angles to flux path in the core of the loading coil.

The production of this hard-drawn wire requires the use of diamond dies, and these were imported from Europe. Early during the war importation became impossible, and our supply of hard-drawn wire was thus seriously curtailed. Fortunately the development of the powdered-iron cores while not completed had reached the stage when the material could be quickly put into commercial production to meet the demand for core material.

The authors then give a historical review of the efforts made by previous experimenters to develop such a material; this is followed by a detailed account of their own experimental work and of methods and results of tests of the electrical and magnetic properties of the material developed.

Powdered-iron cores are now manufactured by the Western Electric Company at Hawthorne, Ill. The present equipment has a capacity of 25,000 pounds of iron powder per week. Satisfactory iron is obtained by electrolysis of a solution containing ferrous sulfate and chloride and ammonium sulfate, using anodes of mild steel and cathodes of polished sheet steel. In each tank there are sixteen cathodes and a corresponding number of anodes. An electric crane lifts only the alternate cathodes at a time, partly for convenience in washing and handling, and so that the operating conditions in the tank will be less violently altered than if all the electrodes must be started fresh at once. After being stripped from the cathode the electrolytic iron is ground in a Hardinge conical-ball mill. These mills operate with automatic feeders and deliver their output to rotating brass sieves having 80 meshes to the linear inch. The portion of the iron which is to be annealed is treated in cast-iron pots which hold about one hundred pounds each. During the process of annealing the powdered iron is sintered to a fairly coherent mass. In order to reduce the iron to its original mesh the annealed product is passed through a rotary rock crusher and a disk grinder. It is then sifted again by means of the jagger tables.

The sifted powder is then rolled with flaked zinc in worm-driven drums and shellacked and dried in similar drums. The latter are provided with steam ejectors for drawing a current of air through the shellacked mass as it dries and is slowly tumbled. For compressing the finished powder into cores there is used a short-stroke, quick-acting hydraulic press, producing a pressure of about 200,000 pounds per square inch of surface area of the finished ring. At times this press has been operated to give as high as 300,000 pounds per square inch. Severe requirements have, therefore, been imposed upon the design and construction of the steel die in which the matrial is compressed. The dies at present in use have been specially designed and treated, and their perfection is such that several thousand rings may be pressed from a single die before it must be discarded because of wear, cracks or distortion. The cores are constructed from the rings obtained.

This process has been in operation for about five years and has produced an enormous number of cores which are today widely distributed over the United States in the telephone plants of the Bell system.—Buckner Speed and G. W. Elmen, *Journal of the American Institute of Electrical Engineers*, July, 1921, pp. 596-609.

CHARGING FOR IDLE CURRENT

THE framing of a tariff to encourage high power-factor on consumers' circuits by charging at a higher rate for reactive than for active current, is discussed by C. G. Carrothers in *Electrical Review* of April 1, 1921. This can either be done by employing two separate meters, one arranged to read in k.w.h. and the other in k.v.h. sin ϕ h., or by a single modified meter such as that of Prof. R. Arno which will give the required result with one reading. The author, however, prefers a two-meter arrangement as being more intelligible to the consumer, and describes an alternative system in which the two meters read k.v.a. cos ϕ h. and k.v.a. sin ϕ h. respectively.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

"ANTHRACOAL"

For the purpose of encouraging discussion at its September meeting the American Institute of Mining and Metallurgical Engineers prepublish abstracts of certain papers. One of these is on "Anthracoal: A New Domestic and Metallurgical Fuel," by Donald Markle, and is reprinted here from *Mining and Metallurgy* for August, 1921:

Anthracoal is a mixture of small particles of anthracite coal and a matrix of practically pure carbon, formed from the distillation of coal-tar pitch or other suitable bitumen. It is a hard, dense, homogeneous mass, with a silvery luster and, in color, varies from silvery to grayish black. When pushed from the oven it develops only partly the fingerlike structure of coke; but, unlike coke, it has a tendency to remain in blocky masses. When struck with a hammer or passed through crushing rolls, it breaks with an irregular fracture, similar to anthracite, but with very little fines. Due to its density, anthracite is harder, tougher, and stronger than coke.

Anthracoal can be made in a coke oven upon the same large scale as bituminous coke and can be produced with little greater expense; therefore it should prove a tremendous factor in utilizing the anthracite culm now going to waste.

The percentage of pitch used varies somewhat with the pitch, the character of the culm, and the method of mixing and grinding the material. In the tests at Syracuse, two grades of pitch were used, one with a melting point of 265° F. and one 280° F.; both worked well. The amount of pitch used varied between 14.8 and 25 per cent, due to the method of proportioning. Ovens that contained 15 per cent pitch and 85 per cent culm, by weight, gave an excellent anthracoal and pushed readily. Ovens that contained 25 per cent pitch and 75 per cent culm also gave an excellent anthracoal but more of a thick carbon scale was noted in the ovens than when the mixture contained less pitch; also, the anthracoal was more porous than that made from the 15 and 17 per cent mixtures. After many tests, both in the coke ovens and in the laboratory, it was found that between 16 and 17 per cent produced the best anthracoal with minimum fines and scale. Using below 16 per cent pitch, the anthracoal showed signs of attrition and not holding together, while above 17 per cent the surplus pitch flowed to the sides of the retort and produced a carbon scale that made a great deal of fines when pushed on to the dock.

A direct comparison between chestnut size of anthracoal and chestnut size of anthracite coal was made by an eight-day test of each in a kitchen range. The range performed the same service in each test, cooking three meals a day, heating water in the boiler, and, in fact, doing exactly the same work in each case. Observations were made as to amount of fuel fired each day, the amount of ashes produced, and the position of the drafts during each run. The fire was started with wood at the beginning of each test and allowed to burn completely out at the end of the eight days. The fire was dampened at night and between meals with equal ease with the anthracoal and anthracite.

The total fuel consumed in each eight-day test was 288.5 lb. anthracoal and 346.52 lb. of anthracite, or 20.1 per cent more anthracite than anthracoal. As exactly the same service was obtained from each fuel, the results show that in this range the chestnut anthracite was 20 per cent less efficient than the anthracoal of the same size.

The evidence and data submitted thus far appear to point to a plant of regenerative non-recovery ovens; that is, a plant where the gas is brought directly from the charge into the flues and regenerative apparatus of the oven instead of passing through cooling coils and other apparatus for abstracting the by-products before it is burned.

The reasons for doing this are as follows:

1. If the gas is cooled first the sensible heat will be lost.
2. Removal of the by-products will lessen the heating value of the gas.
3. The by-products in the anthracoal gas are about one-third to one-half those in the bituminous gas, so that it is doubtful, with the uncertain and changing market, whether the recovery of the by-products would be worth the expense of the by-product apparatus which, in cost, represents one-half the cost of the ovens.
4. A non-recovery oven of the regenerative type will burn the gas direct, have the benefit of the sensible heat in the gas as it comes off the charge, and also have the additional heat value of the by-products which are not removed.
5. The ovens should prove to be self-sustaining and have ample gas for an exceptionally hot retort and quick cooking in the non-recovery type.
6. A non-recovery type oven operating with anthracoal should produce 79 per cent more anthracoal in 24 hours than the same type of recovery oven. As the cost of manufacture in each case is almost the same, with perhaps a little greater expense involved in the preparation of the anthracoal mix, the 79 per cent greater production of anthracoal than coke in 24 hours more than offsets the loss of the by-products.
7. A non-recovery type oven should prove more adaptable to the anthracite region. Its cost will be less to construct than the recovery type, and it will not require a skilled staff of chemists and workmen.
8. No market need be developed or additional sales force required, as in the by-product game, but rather the maximum amount of fuel can be produced, which can be handled in conjunction with the sale of anthracite coal.

Naturally, the success of the anthracoal will not be proved until a plant has been erected and the ovens operated on a commercial scale for a period of time. As a non-recovery regenerative oven has been rarely used in this country, it will embody some changes in design from the regular regenerative type. However, this type of oven has been used with success in Germany and never presented any difficulties, as far as can be learned.

NEW DEVELOPMENTS IN THE MANUFACTURE OF TUNGSTEN AND ITS COMPOUNDS

Hugo Lohmann reports in *Electrochemisches Zeitung*, Vol. 26, pp. 29-33, that he has been able to make comparatively large quantities of the crude metal and to obtain therefrom a thoroughly fused carbide in a specially designed furnace. The latter was of the arc type, but was constructed in such a manner that the principal disadvantages of this kind of furnace—viz., the smallness of the source of heat and the space within which it can prevail—are eliminated. It was possible to melt 5 kg., or 12 lb., of amorphous tungsten within fifteen minutes in this furnace. The current consumption is very low. Besides the carbide of tungsten, carbides of titanium, vanadium, zirconium, silicon, boron and uranium were obtained as well.

The hardness of tungstic carbide is 9.8 on Moh's scale. This substance was produced in large quantities and was used with great success to replace the industrial diamond, bort, in all its applications. By melting the carbide it was found that it could be produced in a strong, compact state so that it could be employed in making dies for wire-drawing machines, in

fabricating cutting tools of all sorts, boring apparatus, etc. There appear to be important economic as well as technical advantages in favor of the carbide.

The melting of tungsten and the making of castings, forgings, etc., with the metal have rendered it usable for many purposes for which it could not be used hitherto. It was found that high-speed cutting tools made from tungsten gave very remarkable results in their durability and the thickness of the cut. Any tool or machine part that must stand up against extreme wear and exceedingly high temperatures caused by frictional resistance or otherwise has been improved very greatly by being made from the pure fused tungsten metal.

The author has prepared molten uranium at a temperature of 3,500 deg. Cent. in large quantities. He has used the metal in making the target in X-ray tubes and found that the results corroborated the theory that the higher the molecular weight of the target metal the more effective the X-ray apparatus. He also used the metal in making the contact points for the spark-plugs of gas engines, and instead of platinum for the contact wire in incandescent light.—Abstract from *Chemical and Metallurgical Engineering.*

SYNTHETIC ORGANIC CHEMICALS

THE regulations issued by the Treasury Department for the enforcement of the dye and chemical control section of the Emergency Tariff Act contain the following definition of synthetic organic chemicals with provisions of interest to the chemical industry.

The terms "synthetic organic chemical and synthetic organic drug," used in said section 501-a of the emergency tariff act are interpreted to apply to any substance which is known commercially as a chemical or drug and which contains carbon in chemical combination with other elements (excepting cyanides, cyanamides, carbides, carbonates and bicarbonates of metals or inorganic radicals), and which has been produced by any chemical process other than that necessary to extract, isolate or purify the substance from a natural source or to effect its separation from a more complex natural compound by hydrolysis or to form a salt.

Products obtained by fermentation, if such fermentation is carried on under controlled conditions, are considered to be synthetic organic chemicals. Distillation which simply separates a substance already formed from other substances does not make the product of such simple distillation a synthetic chemical or drug, but if the substance is subject to destructive distillation the products of such destructive distillation are considered to be synthetic organic chemicals or drugs.

In those cases where a particular substance may be either a natural or synthetic product it should be assumed that the substance is a synthetic product if it is known that the product produced is of a substantial commercial quantity. In cases of doubt the question will be referred to the department.

It is held that compounds or mixtures in part of coal-tar origin are included in the term "mixtures and compounds of such coal-tar products" as it occurs in the act, and that it was not the intent of the act to limit the term to mixtures and compounds wholly of coal-tar origin. When a product has sufficient coal-tar product mixed or combined with it to change materially its identity or character it shall be considered a "mixture or compound of such coal-tar product" within the meaning of the act.

A CHEMICALLY CONTROLLED AUTOMOBILE

THIS was the subject of a paper by George G. Brown before the American Chemical Society at its New York meeting in September.

The average motor car is wasting twice as much energy in unburned gas in the exhaust as it is converting into useful work. This statement becomes obvious when we consider that the thermal efficiency of the average car is not over 15 per cent and from a large number of tests by the Bureau of Mines it was found that "The combustible gas in the average automobile exhaust amounts to 30 per cent of the total heat in a gallon of gasoline."

This loss, entirely preventable, is not only an expensive practice but a criminal waste of a valuable and limited resource.

Gasoline itself is not explosive. It can be exploded only when mixed with air in very definite limited proportions. If these limits are exceeded either by having too large a percentage of gasoline or too large a percentage of air the mixture cannot be exploded.

The combustion or explosion of a gasoline-air mixture as it takes place within an automobile engine is essentially a complicated chemical reaction, and as such is very susceptible to chemical control. The principle of chemical control is to determine the influence of all possible variable factors upon the desired reaction and then so to control these variable factors that the desired reaction will take place as completely and efficiently as possible.

In all industrial combustion problems increased efficiency can be obtained by returning as much heat as possible from the exhaust gases to the combustion zone by preheating the air. This is doubly true in the gasoline engine for hot air not only helps to vaporize the gasoline but also increases the rate of combustion so that a leaner mixture can be burned with increased efficiency. But another factor, known as turbulence, which results from the velocity of the mixture entering the cylinder, has an equally noticeable effect upon the rate of combustion; so that when a car driven under normal load, using the leanest possible mixture, encounters a hill or other added resistance, and slows down, the diminished velocity of mixture into the cylinder decreases the turbulence and velocity of combustion to such an extent that the engine backfires, misses, and may even stop unless some measure is employed to increase the velocity of combustion. This can best be done by supplying a richer mixture until conditions have returned to the former state of constant normal load.

The common experience of every automobile driver is to get the best mileage with a hot engine running on a lean mixture, but to climb a hill or thread a course through traffic with a smooth running, flexible engine a richer mixture is necessary. As it so happens that an over-rich mixture will give a flexible powerful engine although wasting a large proportion of gasoline as unburned gases, while a mixture the least bit too lean causes uneven running, and lack of power, most drivers run their cars on an unnecessarily rich mixture to be certain to avoid the annoyance of backfiring, missing, and difficult starting.

Repeated tests have shown that 30, 35, 40 miles per gallon and even more may be obtained driving at constant speed along a level highway and burning a lean hot mixture. It has always seemed reasonable, in spite of statements to the contrary, to expect that a carbureter could be developed that would automatically deliver the leanest and most efficient mixture possible with every temperature condition when the car is running under light load, and would automatically enrich the mixture according to decreased speed or increased load as the car encounters greater resistance so that quick acceleration, easy hill climbing, and flexibility need not be sacrificed for economy.

It has been found that the two variables, temperature of air and manifold suction, are sufficient in themselves to supply all the automatic control desired, as it is necessary to supply simply a leaner mixture with increased temperature and a richer mixture with increased load.

Working along these lines a carbureter has been designed from a scientific and mathematical standpoint that can be made to deliver a mixture of any proportions desired under any conditions.

It has been found possible, using this carbureter, to obtain 35 to 40 miles per gallon on a standard Ford touring car with equally quick acceleration and even more flexibility than could be obtained with standard equipment giving 20 miles per gallon under the same conditions.

SUBSTITUTES FOR ASH IN AUTOMOBILE BODIES

ASH has always been considered the most desirable wood for use in automobile bodies. It combines the properties of moderate weight, easy workability, high degree of toughness, and comparative freedom from warping. On account of the high price of ash, however, other woods are gradually replacing it in all but the most expensive cars.

The following description given in Technical Note No. 147 by the Forest Products Laboratory gives some of the advantages and disadvantages of the substitute woods as compared with forest grown ash for automobile construction:

Maple.—Hard maple is used for sills in many cars, and in some for the framework of the body and even the floor and running boards. Maple is fully as strong and stiff as a beam or post as white ash, but is not so shock-resistant. It is usually cheaper than ash and runs more uniform in strength. Maple warps very little, in this respect being superior to elm. On the other hand, maple is more difficult to season without checking than ash or elm, and it is said not to hold screws so well in motor car bodies. On account of the smooth, fine texture of maple, paint and enamel rub off it more easily, especially on curved surfaces which receive considerable wear, than off birch, which is slightly more porous. Because of its smooth-wearing qualities and comparative freedom from slivers, maple is preferred to all other woods for the floors of delivery trucks.

Elm.—The principal use of elm is for frames, seat backs, and doors; very little, if any, is used for sills. White elm is preferred to rock elm, except for some of the bent parts, because it is more easily worked and is less subject to warping. For the same reasons lumber from old white elm trees, usually called "gray elm," is preferred to that from younger or vigorously growing trees. Old white elm is not so strong or tough as ash, on the average, but it varies less in strength than ash, especially that which comes from the southern swamps.

Birch.—Yellow birch is a close rival of maple. It is used for sills, framework, and many minor parts. It is said to hold the paint better than maple on exposed parts.

Hickory.—The true hickories are used almost exclusively for spokes and felloes. The pecan hickories, which are somewhat inferior as a class to the true hickories, might be used in body construction, although their hardness and tendency to twist would perhaps prove a serious drawback.

Red Gum.—Red gum is too weak and soft for the sills and other major parts of the frame, but is used for floor boards, seat risers, and other minor parts. One of the principal drawbacks to the use of gum is its tendency to warp with changes in moisture content. Quarter-sawed gum gives less trouble in warping than plain-sawed gum.

Oak.—In automobile construction no distinction is made, as a rule, between the different species of oak or even between the red oak and white oak groups. In truck bodies, oak is one of the leading woods, being used for sills, cross sills, frames, floors, and stakes. In pleasure cars oak is rarely used for the frame or sills. Wormy oak is used for running boards, floor boards, and seats, and some sound oak for instrument boards and battery boxes. Top bows are made almost exclusively of oak, second growth being preferred.

Southern Yellow Pine.—Under this heading are included longleaf, loblolly, shortleaf, and some of the minor southern pines. These have been found adaptable for running boards, floor boards, seat boards and a number of small parts in the seats and frames.

Other Species.—Cottonwood is used for dash boards of pleasure cars and the boxes or bodies of trucks. Sycamore, beech, basswood, yellow poplar, cucumber, tupelo, gum, chestnut, Douglas fir, and western yellow pine have also entered into car body construction to a small extent.

The comparative merits of the different species in the four properties most important in automobile construction are given in the following table, the strength of forest-grown white ash being taken as 100. Actual strength values of these species are to be found in Department of Agriculture Bulletin 556, "Mechanical Properties of Woods Grown in the United States."

Strength of Woods Used in Automobile Construction in Per Cent of the Strength of Forest Grown White Ash

Species	Strength as a beam or post	Stiffness	Shock resisting ability	Hardness
HARDWOODS				
Ash, white, forest grown	100.0	100.0	100.0	100.0
Ash, black	71.3	79.3	90.1	62 3
Ash, white, second growth	122.5	117.6	119.6	118.9
Basswood	59.1	80.6	40.5	29.6
Beech	93.5	96.9	96.0	90.0
Birch, yellow	104.8	116.8	120.6	80.9
Chestnut	66.0	71.9	53.4	49.2
Cottonwood	60.6	79.0	54.3	35.3
Cucumber	85.4	112.4	76.7	54.9
Elm, rock or cork	98.8	92.9	140.5	101.6
Elm, white	79.2	79.5	89.5	57.1
Gum, red	80.7	91.5	75.5	59.0
Gum, tupelo or cotton	81.4	82.5	63.5	77.3
Hickories, pecan	103.5	103.8	119.7	139.6
Hickories, true	126.6	120.2	173.9	150.4
Maple, red	90.0	101.2	78.7	75.4
Maple, silver	66.9	68.5	71.7	64.3
Maple, sugar	104.7	105.9	90.5	103.0
Oaks, all kinds	92.6	101.3	94.9	104.5
Poplar, yellow	67.3	93.8	41.5	37.9
CONIFERS				
Fir, Douglas	95.7	122.1	59 9	58.3
Pine, loblolly	93.7	105.6	71.0	60.0
Pine, longleaf	112.2	122.1	77.7	74.8
Pine, shortleaf	94.1	100.6	69.7	64.0
Pine, western white	75 5	99.7	53.8	37.0
Pine, western yellow	67.0	75.6	42.9	41.0
Spruce, Sitka	69.5	94.1	63.3	44.9

SOLUBLE OILS AND THEIR PRODUCTION

SOLUBLE oils have become an important item in many industrial processes as for example in tanning. The July issue of the *Journal of the American Leather Chemists Association* prints the following abstract of R. Sansone's discussion in *Le Cuir* 10, 13 and 156 (1921), entitled "Notes on Soluble Oils and Their Production."

The commercial soluble oils can be grouped: (1) emulsifiable oils; (2) sulfonated oils; (3) liquid soaps; (4) soluble mineral oils. Without doubt the first emulsifiable oil used in the tannery was prepared from olive oil, preferably from the olive oil of Gallipoli which always contains large quantities of free fatty acids, up to 25 and 30 per cent. In absence of this particular oil any olive oil is submitted to artificial oxidation and upon mixing with water for fat liquor forms a more or less stable emulsion. The high price and food value of olive oil, especially since by simple chemical treatment low-grade olive oils can be rendered edible, are constantly reducing the use in the tannery of this oil which in the near future will be replaced by a mixture of fatty acids and lowest grade olive oil, or simply a mixture of fatty acids with cottonseed, fish or peanut oils treated artificially to give the odor of rancid olive oil. Sulfonated oils may be classed as: (1) with castor oil base; (2) with olive oil base; and (3) with fatty acid base. Sulfonated castor oil while the best is also very expensive. Its value is often wrongly judged from the per cent fatty acids and fatty matter. This method is poor since in many cases it is easy thus to mistake for sulfonated castor oil a product made from cheaper oils. One of the first indications of genuine sulfonated castor oil is its bright color. Comparison of the melting point of the fatty acids with those from

an authentic sample should be made. Rosin soaps are often used in adulteration but these can be readily detected by color and characteristic odor. Sulfonated castor oil can be easily prepared. To the castor oil add ¼ its weight of 66° sulfuric acid keeping the temperature below 35-40° C.; let the mixture stand 24 hours, stirring it frequently; wash out most of the acid with water, siphon off the oil and neutralize remaining acid carefully with ammonia. A well prepared product upon dilution with water and addition of ammonia will remain clear. Vats for sulfonating oils are described. The vats are of hard wood and should have a capacity of 2½ to 3 times the volume of the oil to be treated. They should be provided with a gage and with spigots at different levels for drawing off the various reaction products and wash waters. Agitation during sulfonation preferably should be done by mechanical means. Vats of ordinary wood should be lined with lead as otherwise the action of the acid on the wood gives a dark product. As the sulfonation generates heat, the acid should be added a little at a time, taking at least an hour and the temperature should not rise above 40° C.

Sulfonated castor oils are ordinarily sold as containing 50 per cent fatty acids; sometimes oils are offered having up to 70 per cent and other times down to 33 per cent. All things considered the most suitable oils run 50 to 80 per cent fatty acids. The following tests for sulfonated oils are described: To 100 cc. of water 10 cc. of the sulfonated oil is added and the whole is agitated for some time. Upon standing a perfect emulsion should persist which should become clear upon the addition of ammonia. If the water is hard the emulsion should remain without change for an hour. To 1 liter of water are added 2½ cc. of 50 per cent acetic acid, 5 cc. of 8° Bé solution of calcium acetate and ½ cc. of a 10 per cent solution of the sulfonated oil. No change should be manifested even after boiling. To 1 liter of a solution containing 7.2 gms. of sulfuric acid (66° Bé) and 4.5 gms. of crystallized sodium sulfate is added 1 cc. of the sulfonated oil. Boiling for 1 hour should not cause any kind of separation.

For sulfonation the oil should be of good quality, free from water and the sulfuric acid should not cause any discoloration of the product. Before using any lot of acid it is best to make a complete sulfonation and fat-liquoring laboratory test of it. With the object of reducing the cost of production some manufacturers neutralize the sulfonated castor oil as soon as the acid water has been separated, thus avoiding all water washing; others reduce the quantity of ammonia required by substituting caustic soda for 4/5 of it and using the ammonia only toward the end of the operation. Castor oil has been preferred for sulfonation because in the sulfonated state it forms soluble soaps with the minimum proportion of alkali. Because of the high price of castor oil some manufacturers have returned to the use of olive or other oils; some to mixtures of olive and castor oils; and still others to fatty acids for sulfonation. Olive oil may be sulfonated as follows: 100 kgs. of oil are mixed with 20 kgs. of sulfuric acid (66° Bé) in a container of 500 liters. The mixture is allowed to stand one day and then thoroughly mixed with a solution of 10 kgs. of calcined sodium carbonate until effervescence ceases. The vat is then filled with water and left for about 2 days to clear up after which the acid water is drawn off and the oil mixed with a solution of 4 kgs. of caustic soda in 85 liters of water and neutralization is completed by the addition of ammonia to a faint alkaline reaction. Neutralization should be done at a temperature of 25°-35° C. In the above manner a sulfonated olive oil is obtained which contains 33 per cent of fatty acids. A mixture of sodium sulforicinate and olive oil is often sulfonated, although it is not as certain as separate sulfonation. The sulfonation of oleic acid is important because of the large quantities of this product as a residue from the manufacture of candles and glycerine. One of the most usual preparations is obtained by sulfonating 260 parts of oleic acid with 90 parts of sulfuric acid for 12 hours. The sulfo-oleic acid thus formed is left for 24 hours, then washed with a solution of common salt and neutralized with caustic soda and ammonia. These sulfonated oils are cheap and readily soluble in water. They can be substituted for many purposes in the tannery.

Monopol soap is a special form of sulfonated oil. It is prepared sometimes by treating 100 parts by weight of castor oil with 50 parts of 66° sulfuric acid in such a manner that during the sulfonation no sulfurous acid is developed. The mixture is left to cool during 1 or 2 days with vigorous stirring from time to time. According to these proportions there are about 3 molecules of sulfuric acid for each molecule of castor oil giving thus a higher degree of sulfonation. It is upon this that the success of manufacturing depends. The temperature should be maintained between 25°-30° C. The product thus formed is then treated by one of the following procedures: To 100 kgs. of the above acid mixture, 60 kgs. of 36°-37° Bé caustic soda, are added at once while stirring. The oily mass becomes limpid and yellow. It is left for 2-3 days, during which time sodium sulfate crystallizes out. The crystals are removed and the oily mass is heated up until upon cooling it forms a soap called "Monopol." If the operations have been properly conducted and the necessary quantity of alkali correctly calculated the final product will not be acid enough to turn litmus. The second procedure is to wash each 100 kgs. of the acid mixture with 100 to 200 liters of a warm solution of common salt (25°-30° Bé) to remove the excess of acid. After thorough mixing, the mixture is left for several days and then for each 100 kgs. of the washed oil 39 kgs. of caustic soda (36°-37°) are added at once with stirring. A nearly saturated solution of common salt gives good results in promoting the formation of a solid soap. For the tannery however this is not important and the operation could be concluded after neutralization, leaving the soap in liquid form. Monopol soap is considered an acid soap of very great emulsifying power. If it is heated for 4 hours at 100° C. and then completely neutralized a product of emulsifying power equal to that of sulfonated castor oil is obtained. A soap which dissolves completely in water may be obtained by treating a mixture of 60 parts of oleic acid with 30 parts petroleum oil with a trace of some condensation agent, such as aluminum chloride. The reaction takes place quickly at 60° C., the mass becoming solid and dark. After decanting the necessary amount of alkali is added for saponification. The reaction is based on the property of oleic acid of combining with petroleum oil in presence of a condensation agent.

CHEMISTRY IN FINISHING LACE CURTAINS

W. ALBEET in *Deutsche Färber-Zeitung* discusses the bleaching and finishing of lace curtains in an article abstracted as follows in the August *Color Trade Journal*:

As far as the manufacturer is concerned, lace curtains may be divided into two classes: (1) those that are bleached white, and (2) those that are dyed in various tones of cream color and are unbleached. In the bleaching of lace curtains, owing to the rather delicate nature of the material, as little handling as possible should be given the goods, and the bleaching should be suitably provided with the proper machines and appliances specially adapted to the handling of this material in kier-boiling, washing, bleaching and drying. As far as the bleaching operations are concerned, these are conducted very much as other forms of cotton bleaching. The following treatment is recommended:

(1) Steeping over-night in a weak solution of soda ash;

(2) Boiling for 6 to 8 hours under 1 to 2 atmospheres pressure in a closed kier with a lye containing 10 per cent (on the weight of the goods) of caustic soda;

(3) Washing with warm water in the kier;

(4) Washing thoroughly with hot water in a suitable roller washing machine;

(5) Souring in cold sulfuric acid at 1° Tw. with subsequent steeping in the solution for 1 hour;

(6) Washing to remove the acid and dissolved impurities;

(7) Boiling a second time, using 5 per cent of caustic soda for 5 hours;

(8) Washing again in the roller washing machine;

(9) Chemicking in chloride of lime solution or sodium hypochlorite at 1½° Tw., the goods being steeped in the liquor and the latter circulated for 2 to 3 hours or until a satisfactory bleach is obtained;

(10) Washing in the roller washer;

(11) Souring in sulfuric acid at 1° Tw. with circulation of the liquor;

(12) Washing thoroughly to remove acid.

The goods are finished by passing through a weak bath of soda ash at 110° F., then sizing with starch paste to the desired quality and stiffness. With the cheaper grades of material, filling and loading ingredients such as china clay, etc., are added to the size. If a very stiff handle is desired some gelatin is added to the starch mixture. Sometimes magnesium chloride is also added for weighting, as this absorbs considerable moisture. For tinting, Ultramarine Blue is generally used in the size, although Indanthrene Blue RZ is also an excellent tinting medium. Creamed curtains are, as a rule, not bleached. The tinting may be done with ochre mixed with water, the goods being run through this bath and the ochre being added to the size. For the drying of curtain material specially constructed frames or tenters must be used so that the fabric is not injured, and yet so dried and stretched that the design is symmetrical and not distorted. After drying the goods are finally calendered under pressure.

MODERN GRINDING

HARLOWE HARDINGE in the August 10 issue of *Chemical and Metallurgical Engineering* gives a very interesting discussion in "The Economy of Modern Grinding Methods" from which these questions which should be a guide in purchasing grinding equipment are taken as well as a table showing the modern classification of grinding:

Is it the type of equipment to perform your work properly?

What is the total first cost of equipment and auxiliary apparatus f.o.b. factory?

What is the total cost of freight for equipment and auxiliary apparatus to go with this equipment, if any?

What is the cost of erection, including buildings, foundations, etc.?

What floor space is required?

What head-room is required?

Is the equipment self-contained?

Is it easy to inspect when located in the building as you have planned?

What power is required to start and what power to operate?

Is the equipment and lay-out designed so that it is dustless if grinding dry, or water-tight and clean if grinding wet?

What repair parts will have to be kept on hand?

What will be cost of repairs per ton of material ground?

What labor will be required to operate the grinding equipment? Will it have to be skilled and how much time must be allotted?

What percentage of operating time is assured after the equipment has been in operation one year?

Is the equipment simple in design and does it require constant attention to keep oiled or parts tight?

What facilities are there for feeding or discharging automatically?

Is the unit as a whole flexible—*i.e.*, will it wear itself out if underloaded or overloaded?

What troubles are liable to follow, either in loss of production or otherwise, due to choking or jamming of working parts?

Has estimate of capacity been based upon actual conditions that you will maintain, such as maximum size of feed, fineness of product, moisture content and hardness of material?

CLASSIFICATION OF GRINDING

DRY GRINDING

Granular Grinding

Carborundum, emery, silica and ganister rock	For abrasives.
Salt	For table use.
Iron and metals	For recovery from gangue or waste.
Chemicals	For aid in chemical processes.
Grog	For manufacture of tiles, porcelain ware, etc.
Mica and slate	For roofing.
Asbestos	For obtaining fiber.

Medium Fine Grinding

Limestone	For asphalt filler and agricultural purposes.
Barytes and coal mixture	For manufacture of paint (base).
Phosphate rock	For fertilizer.
Sulfur	For chemical compounds.
Iron and minerals	For concentration or separation by special processes.
Hard rubber	For manufacture of rubber composition.
Sawdust	For chemical purposes.
Cast-iron borings	For chemical purposes.

Fine Grinding

Limestone	For the manufacture of cement.
Clinker	For the manufacture of cement.
Coal—bituminous and anthracite	For burning under boilers, in kilns, driers, furnaces, etc.
Grain—various kinds	For food purposes.
Feldspar	For pottery manufacture.
Mica	For use in tire grades.

Extremely Fine Grinding

Barytes	For use as a paint base.
Filter cake	To prevent formation of lumps in further processes.
Grain	For best grades of flour for food.
Pigments	For the manufacture of paints.
Pumice stone and emery	For dental purposes.
Graphite	For pencils.
Talc	For paper filler, talcum powder, etc.

WET GRINDING

Granular Grinding

Ores	For extraction of minerals by jigging and table concentration.
Clay	For recovery of diamonds.
Graphite schist	For recovery of flake graphite from waste rock.

Medium Fine Grinding

Ores	For extraction of minerals by amalgamation and flotation processes.
Foundry waste	For reclamation of metal contained therein.
Iron pyrites	For manufacture of sulfur.

Fine Grinding

Ores	For extraction of metal by cyanidation.
Mica	For wall paper trade.
Feldspar	For use in pottery manufacture.

Extremely Fine Grinding

Barytes	For paint base.
Carborundum and emery	For glass polishing.
Limestone	For manufacture of whiting.
Pigments in water	For manufacture of colors.
Pigments in oil	For manufacture of oil paints.
Ink	Incorporation of carbon and other materials in oil.

WATERPROOFING COTTON FABRICS

IN the *Textile Colorist* A. J. Hall discusses the properties and preparation of aluminum formate and acetate used in waterproofing. He also outlines the tests which he has found most suitable in exercising the control necessary to the success of the method:

"Although many million yards of fabric are waterproofed each year a thoroughly satisfactory water-resisting material has yet to be produced. The chief difficulty is encountered be-

cause a perfectly waterproofed fabric is usually non-permeable to air, whereas the demand is for a fabric in which water resistance is united with air permeability.

"There are several methods for waterproofing which have met with varying degrees of success. Generally speaking, a rubbered fabric has the most satisfactory water-resisting properties, but as opposed to this, rubber is particularly susceptible to grease and is non-permeable to air. To the same type belong those fabrics waterproofed with a drying oil such as is obtained by mixing raw and boiled linseed oils. In addition to non-permeability to air such fabrics are liable to crack.

"Not much waterproofed fabric (although the process is frequently used for paper) is produced by means of cellulose solutions. But fabric which has been treated with cuprammonium solutions of cellulose is highly resistant to mildew. This is probably because of the presence of a small amount of copper remaining in the fabric.

"In many respects waterproofing with aluminum soaps is the most satisfactory process. Certainly the fabrics so treated do not lose their permeability to air. Their power of water resistance is not exceptionally good, but it is quite sufficient for many purposes. Fabrics proofed with aluminum soaps will withstand a fair amount of handling without marked deterioration. A further good feature of the process is that it can be easily carried out and is conducive to a good output.

"The waterproofing process consists of padding the fabric with a soap solution suitably colored according to the fabric being treated. It is then partially dried on drying cylinders through which a reduced amount of steam is passing. The fabric is then passed through the solution of the aluminum salt and afterwards dried to the usual extent.

"It is obvious that the process cannot be well carried out if the chemicals used are not accurately balanced. While the soap used can be generally obtained of a uniform quality, the acetates and formates of aluminum are always sold in the form of solutions, and so are liable to much variation in strength.

"The strength of aluminum salt solutions is usually determined by their specific gravity. Thus aluminum acetate is usually sold as a liquid, free from iron, and standing at 15-20° Tw. But this standard is considerably indefinite, since the density of the solution is affected by all the soluble impurities present. So that the only way of insuring the success of a waterproofing process is to control rigorously the strengths of the aluminum salt solutions by means of chemical analysis."

RECOMMENDATIONS FOR COTTON RESEARCH

AT the World Cotton Conference recently held in England the following recommendations were made regarding research:

"The Committee on Research and Statistics believe that, in considering the matter of research, the primary aim should be to formulate resolutions which will lead to constructive action.

"It is the belief of the Committee that there is a vital need in the cotton industry for scientific research and the application of exact knowledge.

"It strongly endorses the sentiments expressed by Doctor Crossley when he states that, while business privacy and publication of results would appear to be incompatible, a solution can and must be found, for science demands the free discussion of results between those best qualified to speak, no matter whether they are employed in private, in industrial, or in University Research Laboratories.'"

1. With this belief in mind the committee suggests the following as suitable subjects on which to exchange scientific data:

(a) Methods of testing fibers, yarns and fabric with the object of securing, so far as possible, international methods "and a uniform system of expressing results."

(b) Information regarding the growing of cotton.

(c) Such other problems as may later be agreed upon by the International Cotton Research Committee.

2. That the Committee believe that it is above all important to organize in some way, to make an exchange of information effective, and therefore makes the following recommendations:

(a) That the countries represented at this Conference be urged to form National Cotton Research organizations on the lines of the British Cotton Ind. Research Association.

(b) In order to facilitate research work and the exchange of scientific data, that an International Cotton Research Committee be approved by this Conference.

(c) That the duties of this International Committee shall be to stimulate research in the respective countries and bring together scientific information on which it had been recommended that information should be exchanged.

(d) That each country having delegates to the Group on Research and Statistics of this Conference be hereby asked, through its delegates, to appoint sufficient representatives to this International Cotton Research Committee to represent adequately its various important research organizations and interests. For the purpose of voting, however, at any future Conference, delegates to the Research and Statistics Committee will be chosen in accordance with the Constitution and By-laws of the Conference.

TEMPERATURE SHOCKS IN HEAT TREATMENT

AT the annual meeting of the American Society for Testing Materials the Committee on the Heat Treatment of Iron and Steel submitted notes covering suggestions relative to avoiding temperature shocks in the heat treatment of metals. These notes are quoted herewith:

The advantage of alloy steels over simple steels lies in the fact that they are more sensitive to heat-treatment and capable of giving higher properties when properly handled. The increased sensitiveness to treatment unfortunately is accompanied by a proportionate sensitiveness to failure during treatment, which requires greater care in all treatment operations and necessitates the elimination of abrupt changes in section. The following suggestions are made to overcome this difficulty:

1. Heavy solid alloy forgings should not be allowed to cool, but should immediately be put in an annealing furnace and normalized.

2. High nickel-chrome, chrome-vanadium or any other alloy-steel bars and small forgings liable to shattering should be cooled slowly after rolling by burying in warm ashes or lime to retard the cooling. High carbon, even with a moderate alloy content, increases the risk of cracking.

3. A thorough annealing or normalizing above the upper critical point after rolling or forging eliminates much danger of later troubles due to cracks and strains and leaves the metal in a better condition to secure the maximum effect of the quench.

4. Annealing only does not develop high physical properties, but leaves the metal soft, uniform and ductile. To break up forging and rolling structures which are detrimental the piece should be double annealed, first at 100 to 200 deg. Fahr. above the critical range followed by an anneal slightly above the critical range.

5. In heating for either annealing or quenching, the piece should be slowly and uniformly brought to temperature, the rate depending on grade and section, especially through the brittle range, which is up to 800 deg. Fahr.

6. For quenching, the piece should be uniformly heated above the critical range and introduced into the quenching medium with no delay after leaving the furnace.

7. Quenching is the most drastic treatment operation, and therefore the most dangerous. Alloys or sections subject to water cracks should be quenched in circulating oil.

8. In drawing after quenching the piece must be slowly and uniformly heated to the proper temperature, but may be cooled slowly or rapidly as desired.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Society of Mechanical Engineers

THE OILGEAR—A VARIABLE SPEED- AND FEED-CONTROL SYSTEM FOR MACHINE TOOLS

DESCRIPTION of a speed-control system employing what appears to be some novel devices and permitting a large number of variations without stopping the machine.

The pump unit of the oilgear system comprises a revolving driver carrying five or seven crossheads and plungers with a corresponding cylinder barrel revolving with the driver and carrying the cylinders in which the plungers reciprocate. By shifting the center of the cylinder barrel the stroke may be varied to suit the conditions to be met. This stroke variation may be met either directly by the operator or controlled by an outside influence, such as pressure, temperature, centrifugal force, etc.

The motor unit may either be a simple plunger or a revolving multiple plunger unit similar to the pump, except that in the motor the plungers generally have a constant stroke, so that stroke changing mechanism is absent. Because of this the speed of the motor is dependent upon the rate at which the working fluid is delivered by the pump and it varies as the stroke of the pump is increased or diminished.

In addition to this, there is a third unit called the gear pump and acting as a make-up pump for the system. It draws working fluid which is usually oil from the surplus supply and keeps several pounds' pressure constantly on the intake line of the main pump. It may be also used as a means of rapidly transversing the tool carriage at a speed many times that required for feeding.

The principal unit in the feed-control system is the feed controller. This is essentially a casing including a small variable delivery pump having a capacity suitable for the small volumes called for in feeding tool carriages, a much larger constant delivery pump (gear pump) for rapid traverse, a stroke-changing mechanism whereby the operator can accurately set the variable pump stroke-changing handle, and operating to selectively connect one or the other of the two pumps to the feeding motor according to whether feeding movement or rapid transverse movements are required at the moment.

The plungers are fitted in radial reamed cylinders in the circular cylinder barrel, closely fitted for rotation on a hardened and ground ported pindle and fitted into a swinging arm by means of which the revolving cylinder barrel may be shifted from one side to the other of the revolving driver carrying and operating the plungers. Both driver and cylinder barrel continuously revolve around centers which coincide when the swinging arm is placed in central position and whose distance from one another may be increased in either direction by swinging the arm either to right or left. As the cylinder barrel axis is moved to right or left the length of stroke of the plunger is correspondingly increased, and results in a flow of oil through the pump in direct ratio to the length of stroke. This mechanism also gives a reversal of the flow, oil passing through the pump in one direction when the swinging arm is moved to the right, and in the opposite direction when it is moved to the left.

The cam is made with extreme accuracy, giving a speed variation for the tool carriage capable of the finest degree of adjustment. Moreover, after the cam has been swung about through a certain angle it again returns the cylinder barrel to neutral position, thus cutting off the flow from the high pressure pump and preparing the way for further swing of the control valve which connects the flow from the gear pump to the feed motor, to effect the rapid traverse.

The feed cylinder or motor on a machine tool must have hydraulic fluid on both sides, and the entire system including pipe connections must always be full of fluid under a moderate pressure to exclude air and insure an absolutely steady movement of the tool carriage. The maintenance of this make-up pressure, return of leakage, etc., is an additional function of the gear pump.

Two types of feeding motors are employed—the direct-acting pushing cylinder and the rotary motor.—*American Machinist*, Vol. 55, No. 6, Aug. 18, 1921, pp. 271-274.

HIGH-CAPACITY CONSOLIDATION TYPE LOCOMOTIVES

DURING the past 10 or 12 years locomotives of the Mikado type have to a large extent displaced consolidation in heavy main line freight service. The consolidation is still used to a considerable extent, especially for heavy track service where slow speeds suffice and fuel conditions do not require the boiler and firebox proportions that can be obtained in the Mikado type. The purchase of 40 heavy consolidation type locomotives by the Western Maryland Railway and the use of locomotives of the same type purchased a few years ago by the Delaware and Hudson Company show vitality of this type. In particular, it is claimed that with driving wheels of the size that are suitable for slow speed heavy duty service, it is possible in a consolidation design to use a firebox throat of sufficient depth to install a brick arch without raising the boiler to an excessive height.

Among the practical features of the new Western Maryland locomotives may be mentioned the following:

The frames are 6 inches wide, spaced 41 inches between centers, and each frame is cast in one piece with a single front rail to which the cylinders are bolted. A substantial steel casting, placed just back of the cylinders, extends the full length of the leading driving pedestals and serves as a fulcrum for the driving brake shaft. Guide yoke crosstie is also of cast steel, and it is extended back sufficiently far to brace the second driving pedestals. This crosstie also serves as a support for the driving brake cylinders, one of which, because of the lack of room, is placed in a horizontal, and the other in a vertical position.

The driving boxes are of cast steel, and are fitted with bronze hub faces and brass-lined pedestal faces. Cast iron shoes and wedges are used, the latter being of the self-adjusting type. The driving axles and engine truck axle are of heat treated steel, and flanged tires are used on all the wheels. Flange oilers are applied to the front and back drivers. The ashpan has two hoppers with swing bottoms, both of which are controlled by one handle. Flushing pipes are applied for washing ashes from the slopes of the pan. The injectors and steam turret are placed outside the cab and have extension handles identified by small aluminum plates with raised letters. The equipment includes a breather pipe for providing fresh air while passing through tunnels. This arrangement consists of ½-inch pipe placed across the boiler back head, and having five ¼-inch globe valves equally spaced, each fitted with three feet of ½-inch hose. The air supply is drawn from the brake system.

In the Delaware & Hudson consolidations, the design of the ashpan proved to be quite a difficult problem which was met by the construction of an ashpan having six distinct hoppers and doors. Ample air-way for combustion requirements is provided through a 6-inch opening between the pan and the mud ring. The tender construction is also big for a locomotive of this capacity in that it is supported upon an underframe of

built-up structural shapes with heavy center sill section, such as is employed in car construction.

In the Delaware & Hudson units the per cent of boiler horsepower to cylinder horsepower is higher than in the Western Maryland (92 as compared with 85 per cent) and this difference is ascribed to the relatively larger percentage of firebox heating surface to total heating surface in the Delaware & Hudson Consolidation, since each square foot of firebox surface is equivalent in evaporating capacity to more than 5 square feet of tubular heating surface. This only serves to emphasize the inherent limitation in the consolidation type locomotive. On account of the limited flue length and firebox dimensions, it is impossible to secure horsepower equal to cylinder horsepower in high capacity locomotives of this type without the use of thermic syphons or other means of augmenting firebox or tubular heating surface.—*Railway Review*, Vol. 69, No. 7, August 13, 1921, pp. 197-205.

FLOW OF WATER THROUGH GALVANIZED SPIRAL RIVETED STEEL PIPE

By F. W. Greve

Data of experiments performed in the hydraulic laboratory of Purdue University. The diameters of pipes tested were 4, 6, 8 and 10 inches, respectively. The average spacing of the rivets was ⅞ inch for the smaller and 1⅛ inches for the larger pipe. The rivet heads on the inside of the pipes projected 1/10 inch from the pipe wall and were flattened to reduce the resistance to flow.

The relation of friction head per 100 feet of pipe to velocity of flow both with and against laps, is shown in the original article by a graph. The graphs are straight lines indicating that the head loss varies directly as some power of the velocity. They are nearly parallel lines which demonstrate that the slope varies but little with the size of pipe. From the figure it also appears that the loss decreases with increase of diameter for any given velocity; that the loss is greater for flow against than with laps, and that the difference of loss with and against laps decreases with increase of diameter. It would appear, therefore, that the flow in large sizes approaches the conditions of smooth pipes.

The friction loss may be expressed as $\frac{h}{L} = mv^n$ where $\frac{h}{L}$ is the loss due to friction expressed in feet of water; v is the true mean velocity in feet per second; m is the value of $\frac{h}{L}$ when v is 1 ft. per sec. and n is the slope that the graph expressing the relation of $\frac{h}{L}$ to v makes with the horizontal.

The original article gives a table showing certain of the variations of m and n, these relations being of such a character that they are readily established. On the whole it would appear that the friction loss in galvanized spiral riveted steel pipes when the flow is with the laps is still different from that in smooth cast iron pipes.—*Engineering News-Record*, Vol. 87, No. 4, July 28, 1921, pp. 159-160.

TRENT PROCESS FOR CLEANING POWDERED COAL

By B. P. Hood (Mem. Am. Soc. M.E.)

Description of a process now under investigation by the U. S. Bureau of Mines and U. S. Bureau of Standards. The process belongs to a class of those where differential wetting is used and essentially consists in agitating together powdered coal, water and oil. This produces a partly de-ashed plastic fuel, called an amalgam, the oil selecting the coal particles and largely excluding the water and ash. The amalgam can be freed from water mechanically held by working, much the same as butter is worked. It can be burned by shoveling or forcing through pipe by pressure and can be stored if desired under water.

If an oil is used which can be distilled at a temperature below the distilling temperature of the coal, powdered fuel is reclaimed from the amalgam and the oil may be re-used. If a heavy oil is used and distilled to dryness a coke product may be recovered, although the coal used may have had no coking quality. If the distillation proceed only to a heavy pitch, a mass suitable for briqueting may be made.

From a paper by G. St. J. Perrott and S. P. Kinney of the Bureau of Mines it would appear that in this process the clean separation of mineral matter from combustible matter is obtained and combustible recovery has averaged better than 95 per cent.

It has not been found feasible to treat the lignites without preliminary carbonization, due to the difficulty of forming a coherent agglomerate of the raw lignite and oil.—*Iron Age*, Vol. 108, No. 6, Aug. 11, 1921, p. 323.

BIG CREEK DEVELOPMENT OF THE SOUTHERN CALIFORNIA EDISON COMPANY

By F. H. Rogers

Description of a 30,000 horsepower unit designed to operate under a 680-foot head at a speed of 428 revolutions per minute. It is of the vertical shaft single-runner Francis type and is directly connected to a 22,500-kilowatt 14-pole 50-cycle 11,000-volt generator. The water is led to the turbine through a penstock 2800 feet long, having a diameter of 7 feet at the top and 6 feet at the bottom.

Particular effort was taken to reduce leakage at the runner seals, which is an important factor in the design of high-head units. In this case it is claimed that it is considerably reduced by the use of the Moody labyrinth seal device. In this leakage water must pass through a series of six seals at each of which the velocity head is destroyed owing to changes in section and direction of flow. It is claimed that the effective head causing the leakage is only 1/6 of the head for a single seal and that the use of this device will reduce the leakage to only about 0.9 per cent of the full load quantity, which is about one-third of that which would occur with the single seal.

As the operation of the unit is continued this leakage loss increases, since the wear at the seals is directly proportional to the velocity of flow through the passage and as this velocity is about three times as great for the single seal as compared to the labyrinth seal, the wear at the former would be about three times as rapid as for the latter type. It is claimed that after continuous operation for a period of a year the leakage through the labyrinth seal would be only 22 per cent (as compared with 33 per cent for a new turbine) of the leakage occurring with the single seal.

In the usual design of the guide vane there is constant leakage between the top and bottom of the vane and the distributor plates and as this water is not properly guided by the vane it strikes the runner vanes at an incorrect angle causing considerable trouble. The guide vanes in this plant are of the type known as the Overn disk vane in which two heavy disks are cast at the junction between the vane and the upper and lower seams. When installed in the turbine the faces of these disks are flush with the distributor plates, so that they prevent any flow above or below the guide vane proper, except for that small portion of the vane which extends beyond the disk. As a result all the water is guided to the runner faces at the proper angle, and when the vanes are in the closed position there is very little leakage.

One of the interesting features of the governor control is the method of change from governor to hand control. In former designs this change usually entailed the closing of three or four large governor valves and the opening of three or four smaller hand-control valves under high pressure. This not only take considerable time but might lead to serious trouble in case the operator through excitement closes the valves in wrong sequence. In the present installation the governor is furnished with an automatic device known as the Taylor control system, consisting of plunger valves in the governor base operated by oil pressure from the governor system.—*Power*, Vol. 54, No. 7, Aug. 16, 1921, pp. 244-248.

STELLAR PHOTOGRAPH EVIDENCE FOR EINSTEIN'S RELATIVITY THEORY

B. H. CROOKES, writing in *Chemical News*, on the basis of hitherto unpublished experiments by W. G. Crookes, suggests that the displacements of the star images obtained in the 1919 eclipse, and accepted as evidence of the truth of Einstein's theory, may have occurred, not during exposure, but subsequently during development and fixing. That the latter can occur in photographs of spectra of the elements was suspected, tested, and proved by him, the test being made in the following manner: A negative, with two spectra, slightly overlapping, was selected, which had at one part of it a group of strong lines, and at another part few and weak lines. From this negative a contact positive was printed, and from the positive another contact negative. The two negatives were then measured in the usual manner, along the overlap of the two spectra, and compared, and the following results noted: (a) the whole negative altered in length; (b) the alteration took place in a "concertina" fashion, being greater where the lines were strong and numerous than where they were light and few; (c) one or two lines showed decided displacement with regard to their neighbors in the same spectrum. The conclusion drawn was that during development and fixing the sensitive film was in a state of tension, and yielded to the strain irregularly in proportion to the depth and width it had been altered by the light rays. It would then seem that the spectra had been measured along the very worst line, where distortion would be greatest, and arrangements were being made to alter the shuttering of the spectroscope so that the measurements could be taken along a line only just off the unexposed part of the plate, where distortion would be least, but death intervened, and the alteration was never made. In the case of stellar photographs there would appear to be no line of weakness, but in the eclipse the ring of flames would form a very decided line of weakness, and the author suggests the desirability of examining the possibility of the displacements having arisen from the sensitive films having yielded to strain in its neighborhood during developing and fixing. If this should be the case, a similar effect should be found, he suggests, during an annular lunar eclipse, and it might even be possible to obtain evidence of slight displacement during a close conjunction of a star with Jupiter or Venus when at their brightest. Bright star clusters might also show systematic divergencies between the photographic and visual positions.

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